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Abstract

A review of the foodchain ECOSYS model, which is applied in the European standard decision support systems ARGOS and RODOS, has identified a number of points where elaboration is deemed necessary before ECOSYS should be relied on for Nordic decision making. The present study has been performed to update the ECOSYS model, which in a number of ways does not reflect current state-of-the-art knowledge, and to obtain country-specific data. It is the aim of the PardNor project to collect new data, and thus enable the targeted use of ECOSYS for scenarios involving contamination of specific Nordic areas. The effort in 2007 is targeted on identifying location-specific Nordic data sets describing the typical human diets, fractions of imported food items and animal feeding regimes. For each of the Nordic countries, a dataset has been established describing the typical diets for four different age groups, ranging from young children to senior adults. A comparison of the datasets shows that there are significant differences between consumption rates of some of the important food items. For instance, the average consumption of milk varies by a factor of 4-5 among the Nordic countries, and consumption of leafy vegetables varies by a factor of almost 4. Due to the differences in climate among the Nordic countries and also compared to Southern Germany, for which the default ECOSYS values apply, there are also very significant differences in the production regimes of some food items. Since some countries import practically the entire consumption of some major food items, it is important to generally examine the import patterns for the different Nordic countries. Due to the complexity of current international trade routes, unexpectedly high import fractions were found for some food items, for which the production in the given countries was much more than sufficient to cover the home market. ECOSYS calculations for a scenario showed that the differences in consumption and production patterns could easily lead to a difference in long term ingestion doses by a factor of at least two between the Nordic countries. It was also demonstrated that early phase doses received before countermeasures can be effectively implemented may deviate by at least an order of magnitude. Finally, typical animal feeding regimes have been examined and described for the different Nordic countries. Here it has been found that both the fodder items and the seasonal variation in their application vary considerably.

Key words

Foodchain modelling, ingestion dose

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Contents:

1 Introduction

The two European standard decision support systems, ARGOS and RODOS, have in recent years become increasingly integrated in the Nordic preparedness against nuclear and radiological accidents and incidents. In the event of an emergency, decision making will rest heavily on the reliability of these tools. However, recent investigations have demonstrated that estimates made with the ECOSYS model, which is the ingestion dose module in both of the standard decision support systems, are highly sensitive to variation in a number of input parameters. The default values of these parameters, which are generally adopted uncritically in ARGOS and RODOS, have been shown to be inadequate for two reasons:

i) The ECOSYS system was developed in the 1980's, and very little of the host of information obtained since the Chernobyl accident has been considered. Accordingly, default data values for 'generic' parameters (e.g., specifying deposition of contaminants and their post-deposition behaviour in the environment) do not reflect the best knowledge of today, and in some cases also functional specifications have since been demonstrated to neglect important factors.

ii) The ECOSYS model was parameterised for Southern German conditions, and its originators have always recommended revision of site-specific parameters prior to use in any other area. However, as of today, the model is still used in RODOS and ARGOS with the default parameters.

The overall objective of the PardNor project is to redress these shortcomings specifically with a view to Nordic conditions, and thereby improve the platform for Nordic decision making.

The work that was carried out in this context in 2007 has focused on the collection of model data related to the following three items:

1. Dietary composition in each of the Nordic countries
2. Fractions of consumed food in each Nordic country that are imported from abroad
3. Animal feeding regimes in each of the Nordic countries

2 Dietary composition in each of the Nordic countries

Consumption habits can vary widely between countries, depending on, e.g., the climate and local tradition. For inclusion in the ECOSYS model (and thereby in the standard decision support systems) it is essential to have recent location-specific data for the consumption pattern, so that proper estimates can be made of the doses received by a local population in the event of an incident leading to contamination in food production systems. A survey was first made in all the Nordic countries to assess which data would be available for different age groups on the dietary composition. In-line with the outcome of this and to address as wide a range of discrete age groups as possible, thereby also complying with the methodology used in the ECOSYS model, it was decided to consistently focus on four age groups: infants and young children 1-4 y, teenagers <15 y, young adults (ca. 30 y), and more senior adults (ca. 60 y). For all countries, except for the Faroe Islands, fairly recent survey data are available for such age groups. For some countries separate data for each of the two genders are available. In some cases gender deviations of some significance have been noted, but such differences are not readily accommodated in the framework of the ECOSYS system.

2.1 Dietary composition in Norway

Food consumption in Norway could be approached using three principally different data sets: food supplies, household consumption surveys and dietary surveys [8]. Food supplies have been published annually since 1952, whereas household consumption surveys – covering two week periods – have been performed by Statistics Norway since mid 1970s. Among several dietary surveys the most important for the purpose of PARDNOR are the Norkost studies (1993-94, 1997) and Ungkost-2000. Each of the Norkost surveys covered approximately 3000 men and women from 16 to 79 years of age – grouped in seven age groups. The Ungkost-2000 surveys focused on the age groups 4, 9 and 13 years with ~ 400, 800 and 1000 participants, respectively. In addition, dietary surveys are available for 2 year old children (Småbarnskost, 2002) and infants (Spedkost, 2003-2005).

The information used in Table 1 is mainly from the Norkost-1997 and Ungkost-2000 surveys. However, in some cases - as evident from table footnotes - it was necessary to use supplementary information from food supplies or household consumption surveys in order to attain the degree of detail required by ECOSYS. For instance, total meat consumption – as reported in the dietary surveys, were split up in six types of meat using weighting factors (WFs) derived from production statistics. Similar approaches were applied for cereals, vegetables and fruit/berries.

Table 1 shows the gender averaged, female and male consumption rates in Norway for the four different age groups considered by PardNor. The food products presented are mainly those considered by default in ECOSYS. However, one additional Norwegian foodstuff has been considered, namely brown (“whey”) cheese. The reason for this - besides its importance in Norwegian diets - is that relatively high levels of radioactive caesium were found in this product after the Chernobyl accident. Brown cheese can be made from cow’s milk or goat’s milk, or a mixture of the two. Especially brown goat cheese showed high levels of radioactive caesium after

Chernobyl. Radioactive caesium follows potassium in milk and milk products, so the contaminant will concentrate in the whey. During production of brown cheese the whey is evaporated almost into dryness, and radioactive substances such as caesium will therefore be concentrated 10 times (or more) in the final product (compared with the raw material) [9].

Table 1. Consumption (kg/year per person) of various foodstuffs in Norway - Gender averages (women, men). WF=weighting factor; n=not available/applicable.

	Product	Young children (4 years)	Teenagers (13 years)	Adults (16-29 years)	Seniors (60-79 years)	WF	Refs
	Bread and cereals[a)]	**48 (44, 52)**	**77 (66, 88)**	**101 (80, 122)**	**73 (63, 82)**		**1**
1	Spring wheat, whole grain	n	n	n	n		
2	Spring wheat, flour[a)]	41 (38, 45)	67 (57, 76)	88 (69, 106)	63 (55, 72)	0.87	1,4
3	Spring wheat, bran	n	n	n	n		
4	Winter wheat, whole grain	n	n	n	n		
5	Winter wheat, flour	n	n	n	n		
6	Winter wheat, bran	n	n	n	n		
7	Rye, whole grain	n	n	n	n		
8	Rye, flour[a)]	4.0 (3.6, 4.3)	6.4 (5.5, 7.3)	8.4 (6.6, 10.1)	6.0 (5.2, 6.9)	0.08	1,4
9	Rye, bran	n	n	n	n		
10	Oats[a)]	2.0 (1.9, 2.2)	3.3 (2.8, 3.8)	4.3 (3.4, 5.2)	3.1 (2.7, 3.5)	0.04	1,4
11	Potatoes (fresh)	11 (11, 11)	16 (14, 18)	33 (26, 40)	53 (45, 61)		1
	Vegetables (fresh)[b)]	**17 (18, 15)**	**21 (22, 18)**	**37 (42, 28)**	**51 (56, 46)**		**1**
12	Leafy vegetables[b)]	3.8 (4.1, 3.5)	4.8 (5.0, 4.6)	8.5 (9.6, 7.5)	12 (13, 11)	0.23	1,2
13	Root vegetables[b)]	5.7 (6.1, 5.3)	7.1 (7.4, 6.9)	13 (14, 11)	18 (19, 16)	0.34	1,2
14	Fruit vegetables[b)]	5.1 (5.5, 4.7)	6.4 (6.6, 6.1)	11 (13, 9.9)	16 (17, 14)	0.31	1,2
	Fruit and berries (fresh)[c)]	**29 (30, 29)**	**20 (23, 18)**	**32 (35, 28)**	**51 (56, 46)**		**1**
15	Fruit[c)]	25 (25, 24)	17 (20, 15)	27 (30, 24)	43 (48, 39)	0.85	1,2
16	Berries[c)]	2.4 (2.4, 2.4)	1.7 (1.9, 1.5)	2.6 (2.9, 2.3)	4.2 (4.6, 3.8)	0.08	1,2
17	Milk (incl. yoghurt)	136 (134, 138)	131 (115, 148)	210 (168, 253)	137 (129, 144)		1
18	Condensed milk	n	n	0.2	0.2		2
19	Cream (incl. sour cream)	0.7 (0.7, 0.7)	1.5 (1.5, 1.5)	2.2 (2.2, 2.2)	4.7 (4.4, 5.1)		1
20	Butter	0.5 (0.7, 0.4	0.4 (0.4, 0.4)	1.1 (0.7, 1.5)	1.3 (1.1, 1.5)		1
21	Cheese, Rennet coag.[d)]	4.2 (4.4, 4.0	7.1 (6.9, 7.3)	8.8 (8.0, 9.5)	6.9 (7.3, 6.6)		1
22	Cheese, Acid coag.	n	n	n	n		
	Brown cheese[e)]	**1.6 (1.8, 1.5**	**1.1 (1.1, 1.1)**	**2.6 (2.6, 2.6)**	**4.2 (3.7, 4.7)**		
23	Goat's milk	n	n	n	n		
24	Sheep milk	n	n	n	n		
	Meat/meat products[f)]	**23 (23, 24)**	**40 (35, 45)**	**42 (32, 52)**	**31 (26, 35)**		**1**
25	beef (cow)[f)]	2.7 (2.6, 2.8)	4.7 (4.1, 5.3)	4.9 (3.8, 6.0)	3.6 (3.1, 4.1)	0.12	1,3
26	beef (bull)[f)]	4.5 (4.4, 4.7)	7.8 (6.7, 8.8)	8.1 (6.2, 10.0)	6.0 (5.1, 6.8)	0.19	1,3
27	Veal[f)]	0.2 (0.2, 0.2)	0.3 (0.3, 0.4)	0.3 (0.3, 0.4)	0.3 (0.2, 0.3)	0.01	1,3
28	Pork[f)]	9.4 (9.1, 9.7)	16 (14, 18)	17 (13, 21)	12 (11, 14)	0.40	1,3
29	Lamb/sheep[f)]	2.2 (2.1, 2.2)	3.7 (3.2, 4.2)	3.9 (3.0, 4.8)	2.9 (2.4, 3.3)	0.09	1,3
30	Chicken[f)]	4.3 (4.1, 4.4)	7.3 (6.3, 8.3)	7.7 (5.9, 9.4)	5.6 (4.8, 6.4)	0.18	1,3
31	Roe deer meat	n	n	n	n		
32	Eggs	3.3 (2.9, 3.7)	3.3 (2.9, 3.7)	6.0 (4.7, 7.3)	5.7 (5.5, 5.8)		1
33	Beer	n	n	40 (26, 54	14 (6, 23)		1

[a)] Dietary data reported as bread/cereals [1]. Consumption of different flour types calculated from [1] using weighing factors based on data from the Norwegian agricultural authority for the period 2001-2006 [4]. All wheat and rye are assumed to be flour.

[b)] Data regarding vegetables, generally, were available from dietary surveys [1]. Leafy, root and fruit vegetable weighting factors derived from household consumption surveys 2003-2005 [3]. Leafy vegetables include cabbage, whereas root vegetables include onions and mushrooms.

[c)] Consumption of fruit and berries (excluding juice) from dietary surveys [1]. Fruit and berries weighting factors derived from household consumption surveys 2003-2005 [3].

[d] For the sake of simplicity, all white cheese consumed in Norway are assumed to be "rennet". More correct data may be obtained at a later stage (if considered necessary).

[e] An important fraction of the cheese consumed in Norway is "brown cheese" made out of whey from goat's milk. Unfortunately, this type of cheese is not presently covered by ECOSYS.

[f] Total meat consumption available from dietary surveys [1]. Production statistics 2001-2005 [4] used to derive weighting factors for various types of meat. Note that beef (bull) also comprises heifer meat, whereas "chicken" is actually poultry.

The dietary information specified above pertains to the general population. Since the early 1960s, however, it has been known that reindeer herders are particularly vulnerable to radioactive contamination due to their special diet with high intake of reindeer meat (and other natural products). National radiation protection authorities in Norway have since 1965 monitored radioactive caesium in reindeer herders from northernmost Norway, and after the Chernobyl fallout this monitoring was extended to also include reindeer herders from the heavily contaminated areas in central Norway [5]. In connection with (and as a supplement to) this monitoring programme, several dietary surveys have also been carried out among sami population groups - emphasising "local" products such as reindeer, game, freshwater fish, wild mushrooms, and wild berries. The dietary surveys have confirmed that the main source of radiocaesium in reindeer herders is reindeer meat, contributing about 90 % of the radiocaesium intake in central Norway [6]. Unfortunately these foodstuffs are not a part of the default diet list of ECOSYS. NRPA's dietary surveys among reindeer herders in central and northernmost Norway can, however, be used to obtain an overview of these special diets, but inclusion in the ECOSYS model would require further steps, including definition and implementation of transfer parameters for various radionuclides to these products.

As an example, some results from the latest dietary survey performed in central Norway are summarised in Table 2. For more information see [6].

Table 2. Consumption of various natural foodstuffs among reindeer herders in Central-Norway 2002 (kg/year per person), n=37.

Foodstuff	Mean	SD	Min	Max	Comments	Ref
Reindeer	36	26	1	130		6
Game	6.6	7.3	0.0	25	Mainly moose	6
Freshwater fish	5.8	7.3	0.0	40		6
Wild berries	15	14	0.3	58		6
Mushrooms	2.7	5.1	0.0	20		6

For comparison: the general Norwegian population consume about 0.5 kg reindeer meat per per capita per year, whereas a special dietary survey among rural people in Oppland county showed that the people in this area consumed about 3.2 kg/year in 1996 [7].

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2.2 Dietary composition in the Faroe Islands

There are only two publications on nutritional investigations in the Faroe Islands, one from 1936-37 (Gudjonsson, 1940) and one from 1981-82 (Vestergaard and Zachariassen, 1987). As in most countries, the dietary composition in the Faroe Islands has changed considerably with time, also during the latest 25 years. The

referred publications are focusing on nutritional aspects, and it is only possible to derive a few dietary components from the publications. Gudjonsson (1940) documents significant geographic variability in food consumptions in the 1930's.

Table 3 shows results from Vestergaard and Zachariassen (1987).

Table 3. Daily mean consumption of foodstuffs (gram/day/cap) in 1981-82 according to Vestergaard and Zachariassen (1987).

	Dairy products	Faroese Mutton	Marine Fish	Potatoes	Grain products	Vegetab.	Whale Meat	Whale Blubber
Faroes	390	68	72	192	215	32	12	7

Table 4 shows results from Gudjonsson (1940).

Table 4. Daily mean consumption of foodstuffs (gram/day/unit) in 1936-37 according to Gudjonsson (1940). The units are as defined in Table 5.

	Milk	Dried lamb/sheep meat + dried marine fish	Rye bread	Wheaten bread	Whale blubber
Faroes	681	22	232	78	15

Table 5 shows a set of factors used by Gudjonsson for the calculation of diets for specific population groups with respect to gender and age.

Table 5. Definition of units used by Gudjonsson (1940).

Male	Female	Boys	Girls	Child							
Adults	Adults	14year	14year	12-14y	10-12y	8-10y	6-8y	3-6y	2-3y	1-2y	0-1y
1.00	0.83	1.00	0.83	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2

An estimate of the consumption of different food components has been published by Aarkrog (1979); Table 6. This refers back to estimates made in 1962 by Prof. E. Hoff-Jørgensen, nutritional consultant to the Danish Atomic Energy Commission, and two consultants in domestic science in the Faroe Islands, who assumed a daily per capita intake of ca. 3000 cal (Aarkrog et al., 1963).

Table 6. Annual mean consumption of foodstuffs (kg/y/cap) as referred to by Aarkrog (1979).

Faroese products		Danish products	
milk	109.5	milk	36.5
potatoes	91.0	cheese	7.3
mutton	18.5	rye bread	39.4
whale meat	9.3	white bread	59.1
birds	4.6	leaf vegetables	12.8
fish	91.0	root vegetables	7.2
water	548.0	grits	7.3
		fruits	18.0
		eggs	4.6

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2.3 Dietary composition in Sweden

The dietary data from Sweden mainly originate from the 'Riksmaten' survey made in 1997-98 (Table 7). This survey gave specific information related to age, gender, regions of Sweden, education, etc. A previous investigation in 1989 had even more age groups represented, and the data for children originates from an additional study made in 2003.

Table 7. Consumption (g/day) of various foodstuffs in Sweden. Mean values for females and males (girls and boys) in different age categories. For comparison with the other Nordic countries, representative values for 1-4 year olds, teenagers, young adults and senior adults are derived and presented in grey shaded columns. Notation "mean" represents the mean value of females and males (girls and boys).

Product	Age category (y)																																	Whole population[13]	
	g	4[14] b	mean	g	8[14] b	mean	g	12[14] b	mean	1-4 Infants & young children[16]	5-15 "Teen-agers"[17]	f	17-24 m	mean	f	25-34 m	mean	ca. 30 Young adults[11]	f	35-44 m	mean	f	45-54 m	mean	f	55-64 m	mean	ca. 60 Senior adults[12]	f	65- m	mean		
Spring wheat, whole grain[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spring wheat, flour[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**156,4**	-
Spring wheat, bran[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winter wheat, whole grain[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winter wheat, flour[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winter wheat, bran[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rye, whole grain[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rye, flour[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**20,8**	-
Rye, bran[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oats[9]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**12,3**	-
Potatoes[4]	75	82	**78,5**	100	107	**103,5**	103	126	**114,5**	**78,5**	**109**	101	139	**120**	96	146	**121**	**121**	111	163	**137**	123	188	**155,5**	133	190	**161,5**	**161,5**	143	195	**169**	**229**	-
Leafy vegetables[1]	40	38	**39**	54	50	**52**	47	37	**42**	**39**	**47**	90	67	**78,5**	107	75	**91**	**91**	112	91	**101,5**	123	87	**105**	120	84	**102**	**102**	121	96	**108,5**	-	-
Root vegetables[2]	9	8	**8,5**	13	12	**12,5**	7	6	**6,5**	**8,5**	**9,5**	8	4	**6**	10	10	**10**	**10**	14	11	**12,5**	16	20	**18**	19	12	**15,5**	**15,5**	22	17	**19,5**	-	-
Fruit vegetables	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fruit[3]	115	120	**117,5**	105	97	**101**	76	59	**67,5**	**117,5**	**84,25**	99	50	**74,5**	111	84	**97,5**	**97,5**	132	94	**113**	166	126	**146**	187	119	**153**	**153**	230	163	**196,5**	-	-
Berries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Milk[5]	367	418	**392,5**	443	528	**485,5**	370	468	**419**	**392,5**	**452,25**	320	490	**405**	349	393	**371**	**371**	282	332	**307**	286	337	**311,5**	330	367	**348,5**	**348,5**	328	404	**366**	**304,7**	-
Condensed milk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	<0,5
Cream	5	4	**4,5**	4	5	**4,5**	5	4	**4,5**	**4,5**	**4,5**	4	2	**3**	3	2	**2,5**	**2,5**	3	3	**3**	4	2	**3**	3	2	**2,5**	**2,5**	3	1	**2**	**27,9**	-
Butter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**4,1**	-
Cheese, Rennet coagulation[6]	8	8	**8**	10	11	**10,5**	11	11	**11**	**8**	**10,75**	30	33	**31,5**	29	32	**30,5**	**30,5**	29	30	**29,5**	28	35	**31,5**	26	31	**28,5**	**28,5**	24	28	**26**	**48,8**	-
Cheese, Acid coagulation[6]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goat's milk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sheep milk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
beef (cow)[7, 15]	55	59	**57**	85	92	**88,5**	77	97	**87**	**57**	**87,75**	88	123	**105,5**	93	131	**112**	**112**	96	144	**120**	100	133	**116,5**	101	114	**107,5**	**107,5**	102	109	**105,5**	**69**	Veal included
beef (bull)[7]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Veal[7]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pork[7]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**98,1**	-
Lamb[7]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**3**	-
Chicken[7]	12	13	**12,5**	17	17	**17**	17	16	**16,5**	**12,5**	**16,75**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**39,2**	-
Roe deer meat[7]	-	-	-				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**5,8**	-
Eggs[8]	7	5	**6**	5	6	**5,5**	4	5	**4,5**	**6**	**5**	9	8	**8,5**	14	14	**14**	**14**	13	14	**13,5**	17	15	**16**	17	18	**17,5**	**17,5**	16	23	**19,5**	**31,5**	-
Beer[10]	-	-	-	-	-	-	-	-	-	-	-	98	184	**141**	101	238	**169,5**	**169,5**	154	283	**218,5**	149	320	**234,5**	132	205	**168,5**	**168,5**	115	229	**172**	**72,1**	-

1) Vegetables and vegetable dishes. Legumes not included.
2) Roots (excl. potatoes) and dishes
3) Fruit and berries
4) Potatoes and potato dishes

5) Milk, fermented milk & yoghurt
6) Different types of cheese are not separated in the reference
7) Not separated in the reference. Given for meat & poultry incl. dishes. Sausages & sausage dishes not included. Blood dishes not included.
8) Eggs and egg dishes
9) Not separated in the reference. See Bread, Porridge & gruel, Cereals & müsli.
10) Alcoholic beverages
11) Equals age category 25-34 y
12) Equals age category 55-64 y
13) From ref. (SJV, 2006). Total consumption, including deliveries to food industry.
14) From ref. (SLV, 2003)
15) Separated meat and pultry for children categories.
16) Equals age category 4 y
17) Mean of age categories 8 y and 12 y.

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2.4 Dietary composition in Finland

Information on the consumption of foodstuffs in Finland is available in the statistics of food balances based on the annual production and consumption of Finland's most important food commodities by dividing the total sum by the population figures. In addition, at intervals of five years, consumption of foodstuffs is estimated with studies based on random sample interviews.

The study on mean daily consumption of food groups was made in five areas in Finland during January and April in 2002. The aim of the study was to measure the average food and nutrient intake. A random sample including 2007 participants aged from 25 to 65 years was taken from the population register. For the dietary assessment, the participants were interviewed by the 48-h recall (yesterday and the day before that). According to the National FINDIET 2002 Study, dietary energy intake was 9.2 MJ/day among men and 6.6 MJ/day among women. Among men, dietary energy intake was highest in the eastern parts of Finland, but there were no regional differences in the energy intake of women. Women consume more vegetables (as fresh vegetables and salads), fruit and berries than men, whereas men consume more meat and potatoes. The consumption of fish is equally common in men as in women.

Since 1990s clear trends in the consumption of several foodstuffs can be observed. In the consumption of liquid milk and butter the trend is clearly negative, while a positive trend can be observed in the consumption of cheese, yoghurt, poultry meat, fresh vegetables. In cereals the consumption of wheat has increased in parallel with

the decrease of rye consumption. The consumption of fresh vegetables has increased over 30% since 1990s.

In the group of meat the biggest change has been the increase of the consumption of poultry meat, which has doubled since the beginning of 1990s. At the same time the consumption of beef has decreased about ten percent while the consumption of pork has remained almost constant. The production of chicken in Finland reached 30 million kg in the beginning of 1990s and doubled by the end of the decade. In 1980 the annual consumption of chicken in Finland was about 15 million kg, in 2004 nearly 70 million kg, and it is foreseen to be over 80 million kg in 2012. The consumption rate per person was 13 kg/year in 2004, and according to predictions it will reach 15 kg/year in 2012.

The consumption of liquid milk has decreased about 20% since the 1990s, while the consumption of cheese has increased over 30%.

Seasonal variation is seen in the statistics of marketed vegetables. According to the vegetables balances, greenhouse vegetables are bought by households approximately 40 per cent more during the second and the third quarters of year than during the first and fourth quarters. Buying of potato and onion by households is fairly even throughout the year, whereas cabbage is bought during the third quarter twice as much as at other times. Buying of fresh root vegetables is lowest during the second quarter of the year, approximately half of the amount bought at other times. Frozen vegetables are consumed 4.6 kg per year.

The average calculated ingredient consumption in Finnish diet (only the items that can be included in ECOSYS are shown) is given in Table 8 for one- and two-year-old children, men, women, and the mean for adults. Data for children dates back to the beginning of 1990s and is available only for one- and two-year-old children.

Table 8. Consumption of foodstuffs in Finland.

Product	Consumption (kg/y)			
	1- to 2-year-old children	Men	Women	Gender average
Spring wheat, whole grain	31[9]	-[1]	-[1]	-[1]
Spring wheat, flour		29.2	21.5	25.0
Spring wheat, bran		-[1]	-[1]	-[1]
Winter wheat, whole grain		-[1]	-[1]	-[1]
Winter wheat, flour		-[1]	-[1]	-[1]
Winter wheat, bran		-[1]	-[1]	-[1]
Rye, whole grain		-[2]	-[2]	-[2]
Rye, flour		22.3	14.2	17.9
Rye, bran		-[2]	-[2]	-[2]
Oats		-[3]	-[3]	4
Potatoes	27	42.3	27.7	34.4
Leafy vegetables	26[10]	-[3]	-[3]	12.5
Root vegetables		10.6	13.1	12.0
Fruit vegetables		17.9	21.2	19.7
Fruit	85[11]	-[3]	-[3]	71.7
Berries		-[3]	-[3]	14.5
Milk	188[12]	124.1	78.8	99.4
Condensed milk	-	-[4]	-[4]	-[4]
Cream	-	-[3]	-[3]	6.4
Butter	-	5.8[5]	3.3[5]	4.4[5]
Cheese, Rennet coagulation	-	15.7[6]	13.5[6]	14.5[6]
Cheese, Acid coagulation	-			
Goat's milk	-	-[4]	-[4]	-[4]
Sheep milk	-	-[4]	-[4]	-[4]
beef (cow)	23[13]	8.4[7]	5.5[7]	6.8[7]
beef (bull)				
Veal				
Pork		12.8	8.4	10.4
Lamb		-[3]	-[3]	0.4
Chicken		8.0	6.9	7.4
Roe deer meat		-[3]	-[3]	1.8[8]
Eggs	-	7.7	5.5	6.5
Beer	-	-	-	85

[1] Only total wheat consumption is known. Wheat in Finland is mainly spring wheat.
[2] Only total rye consumption is known.
[3] Only consumption per person known.
[4] Unknown, consumption very small.
[5] Includes all milk fats.
[6] Includes all kinds of cheese, relation unknown.
[7] Includes all beef.
[8] Includes reindeer meat and game meat instead of roe deer meat consumption. Consumption of roe deer meat in Finland is insignificant compared to that of other game meat.
[9] Includes all cereal products.
[10] Includes all vegetables.
[11] Includes fruit and berries.
[12] Includes milk and milk products.
[13] Includes meat and meat products.

This ECOSYS default diet list does not include consumption of wild products, which are important in assessing the total ingestion dose. In Finland, a major part of the ingestion dose comes today from wild products, fresh-water fish, mushrooms, wild berries and game meat. Since these wild products may be representative of a very large area, comprising very different degrees of contamination, their actual contamination level can be very difficult to predict, and the consequences of their consumption thus subject to very large uncertainty. The annual consumption rates of these product types, which can not readily be included in ECOSYS, are:

Fish: all fish 14 kg/y, fresh-water fish 2.5 kg/y
Mushrooms: 1.5 kg/y
Wild berries: 8 kg/y
Game meat : 1.2 kg/y
Reindeer meat: 0.6 kg/y

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2.5 Dietary composition in Iceland

The information on recent dietary surveys (Table 9) is available in a series of recent reports (see references). The reports themselves do not differentiate between different types of meat, but some information (availability) can be extracted from knowledge of production, import and export. There is also included a reference to a Nordic-Baltic study (NORBAGREEN 2002). Unfortunately, no information is available for the youngest population group.

It was pointed out to us that a compilation of the availability of various types of foodstuffs could be relevant for our work. This compilation does not include any dietary classification (gender, age groups etc), but it covers currently the period 1956 – 2005 and it is fairly detailed concerning the different types of foodstuffs covered. Most importantly, information of this type has been gathered in the same way (harmonised classification) in all the Nordic countries. This information could be used with dietary information to estimate e.g. how much of the consumed meat is lamb, pork, chicken etc.

It was also pointed out to us that EFSA (European Food Safety Authority) is starting a European survey on food consumption with the aim of being able to assess the potential consequences of food contamination. At present this does not include radioactive substances, but it is possible that they may be included at a later stage. The methodology seems to be similar to what we know from our field, including identifying critical groups. The survey will focus on the adult group (16-64).

Table 9. Consumption of foodstuffs in Iceland (kg/y).

	9 y Gender avg.	**15 y** Gender avg.	**20-39 y** Female	**20-39 y** male	**20-39 y** Gender avg.	**40-59 y** Female	**40-59 y** male	**40-59 y** Gender avg.	**Food availability 2005** (production+ import-export)
Spring wheat, whole grain	n	n	n	n	n	n	n	n	
Spring wheat, flour	n	n	n	n	n	n	n	n	
Spring wheat, bran	n	n	n	n	n	n	n	n	
Winter wheat, whole grain	n	n	n	n	n	n	n	n	
Winter wheat, flour	n	n	n	n	n	n	n	n	
Winter wheat, bran	n	n	n	n	n	n	n	n	
Rye, whole grain	n	n	n	n	n	n	n	n	
Rye, flour	n	n	n	n	n	n	n	n	
Rye, bran	n	n	n	n	n	n	n	n	
Oats	n	n	n	n	n	n	n	n	
Potatoes (fresh potatoes)	16,1	17,2	16,1	27,4	21,7	32,1	37,6	34,9	
Leafy vegetables	n	n	n	n	n	n	n	n	

Root vegetables (all vegtab., fresh)	16,4*	19,3*	33,2*	37,6*	35,4*	42,0*	39,4*	40,7*	
Fruit vegetables	n	n	n	n	n	n	n	n	
Fruit	n	n	n	n	n	n	n	n	
Berries (fruits and berries total)	34,3	25,6	26,3	19,0	22,6	33,9	24,8	29,4	
Milk (low fat milk)	86,1	81,8	46,0	51,8	48,9	24,5	48,5	36,5	
Condensed milk (whole milk)	69,7	49,6	24,5	56,6	40,5	24,5	32,9	28,7	
Cream	n	n	n	n	n	n	n	n	
Butter	n	n	3,3	5,1	4,2	4,0	6,2	5,1	
Cheese, Rennet coagulation	n	n	n	n	n	n	n	n	
Cheese (all cheese)	8,0	12,8	12,0	17,9	15,0	12,4	13,5	13,0	
(Goat's milk)	n	n	n	n	n	n	n	n	
(Sheep milk)	n	n	n	n	n	n	n	n	
beef (cow)	n	n	n	n	n	n	n	n	
beef (bull)	n	n	n	n	n	n	n	n	17.9 (beef and veal)
Veal	n	n	n	n	n	n	n	n	
Read meat total	13,9	16,8	12,4	25,9	19,2	18,3	24,5	21,4	
Pork	n	n	n	n	n	n	n	n	25,7
Lamb	n	n	n	n	n	n	n	n	12,9
Fowl (incl. chicken)	6,2	3,7	8,0	5,8	6,9	5,5	9,5	7,5	20.6 (poultry)
(Roe deer meat)	n	n	n	n	n	n	n	n	
Eggs and egg products	1,5	2,9	2,9	6,2	4,6	4,0	4,7	4,4	
Beer			23,7	61,3	42,5	11,3	38,3	24,8	

* sum of root vegetables and leafy vegetables

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2.6 Dietary composition in Denmark

The latest surveys of Danish consumption habits were initiated in the period 2000-2002, where a total of 4000 persons in age groups between 4 and 75 years contributed (Fagt et al., 2002). Since then, annual follow-up surveys have been made, incorporating input from about 1000 individuals per year. Compared with the previous survey from 1995, for instance, the intake of morning cereals by children (ages 4-14) is in 2002 halved, whereas it is unchanged for adults. The same pattern is seen for the consumption of rye bread. Also, the butter consumption has gone down by about one-third, but the consumption of green salad and fruit has gone up by more than 50 %. The survey also revealed that there can be some (rather limited, but significant) geographical variation within the country. For instance, inhabitants of Copenhagen consume about one-third less potatoes than do villagers (Groth & Fagt, 2002). ECOSYS works with discrete values for consumption rates, and not with statistical distributions. Therefore, 'critical group' individuals consuming higher than average rates of particularly strongly contaminated food products might be missed out. Average consumption rates for the four population (age) groups generally examined in the PardNor project are shown for Denmark in Table 10.

Table 10. Typical consumption of foodstuffs in Denmark (kg/y) for four age groups, gender-specific and gender average figures.

Consump-tion (kg/y)	**Young children (1-4 y)**			**Teenagers (13-16 y)**			**Adults (ca. 30y)**			**Senior adults (ca. 60 y)**		
	f	**m**	**avg**	**f**	**m**	**avg**	**f**	**m**	**avg**	**f**	**m**	**avg**
Spring wheat, whole grain	n[6)]	n	n	n	n	n	n	n	n	n	n	n
Spring wheat, flour	n	n	n	n	n	n	n	n	n	n	n	n
Spring wheat, bran	n	n	n	n	n	n	n	n	n	n	n	n
Winter wheat, whole grain	n	n	n	n	n	n	n	n	n	n	n	n
Winter wheat, flour[1)]	18,3	19,3	18,8	36,5	40,9	38,7	40,5	49,6	45,1	35,0	40,9	38,0
Winter wheat, bran	n	n	n	n	n	n	n	n	n	n	n	n
Rye, whole grain	n	n	n	n	n	n	n	n	n	n	n	n
Rye, flour [2)]	18,6	20,8	19,7	17,9	21,5	19,7	24,1	31,8	27,9	24,5	28,5	26,5
Rye, bran	n	n	n	n	n	n	n	n	n	n	n	n
Oats	1,5	2,9	2,2	1,8	2,2	2,0	1,5	2,6	2,0	0,7	1,8	1,3

Potatoes	13,5	14,6	14,1	26,6	30,3	28,5	32,9	50,7	41,8	34,7	51,1	42,9
Leafy vegetables	2,2	1,8	2,0	15,3	16,1	15,7	18,6	14,2	16,4	11,3	7,3	9,3
Root vegetables	11,0	11,0	11,0	10,6	11,3	11,0	20,4	16,4	18,4	29,9	21,9	25,9
Fruit vegetables	n	n	n	n	n	n	n	n	n	n	n	n
Fruit [3]	82,5	83,6	83,0	42,0	39,1	40,5	69,0	47,8	58,4	120,1	86,1	103,1
Berries	n	n	n	n	n	n	n	n	n	n	n	n
Milk	144,5	150,4	147,5	135,8	152,6	144,2	71,5	89,4	80,5	70,1	123,0	96,5
Condensed milk	n	n	n	n	n	n	n	n	n	n	n	n
Cream	1,8	1,8	1,8	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1
Butter	1,1	1,1	1,1	3,3	3,3	3,3	2,9	5,8	4,4	5,8	7,3	6,6
Cheese, Rennet coagulation [4]	1,7	1,7	1,7	5,2	6.8	6	7,1	8,5	7,8	7,1	10,1	8,6
Cheese, Acid coagulation [4]	0,5	0,5	0,5	1,7	2,3	2	2,4	2,9	2,6	2,4	3,4	2,9
Goat's milk	N	N	N	n	n	n	n	n	n	n	n	n
Sheep milk	n	n	n	n	n	n	n	n	n	n	n	n
beef (cow)[5]	0,7	1,1	0,9	5,8	7,3	6,6	6,6	12,4	9,5	11,0	14,6	12,8
beef (bull)[5]	0,7	0,7	0,7	2,2	2,9	2,6	2,9	5,1	4,0	4,4	5,8	5,1
Veal	n	n	n	n	n	n	n	n	n	n	n	n
Pork	4,4	4,4	4,4	11,7	11,7	11,7	14,6	15,7	15,1	16,8	23,4	20,1
Lamb	0,4	0,4	0,4	0,4	0,7	0,5	0,7	1,5	1,1	0,7	1,1	0,9
Chicken	1,8	1,8	1,8	4,4	5,5	4,9	4,0	4,0	4,0	2,9	4,4	3,7
Roe deer meat	n	n	n	n	n	n	n	n	n	n	n	n
Eggs	1,8	1,5	1,6	1,8	1,8	1,8	2,9	4,4	3,7	3,3	5,1	4,2
Beer	0	0	0	n	n	n	22,3	118,3	70,3	22,3	118,3	70,3

[1] Only total wheat consumption is known. By far the major part is assumed to be flour. Winter wheat is clearly dominant in Denmark.
[2] Only total rye consumption is known. The major part is assumed to be flour.
[3] Fruit includes berries here.
[4] Acid/rennet relationship is etimated on the basis of production figures of different cheeses and their import and export figures. About 75 % of the total consumption in Denmark of Danish cheese is rennet produced (sources: Arla Foods, Mejeriforeningen).
[5] Bull/cow fractions are estimated on the basis of information from Danish farmers.
[6] 'n' means figure not known or excluded due to uncertainty in figures.

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3 Fractions of consumed food in each Nordic country that are imported from abroad

The standard decision support systems applied in the Nordic countries, ARGOS and RODOS, enable the consideration of a fraction of each dietary component being imported, through the inclusion of the ECOSYS model, which has this feature. The structure applied in ECOSYS assumes that the imported fraction of each food product originates from an uncontaminated area. Obviously, import as well as export figures may change abruptly in the aftermath of a serious contaminating incident. However, for decision making purposes, a sudden forced increase in the import fraction should be regarded as a countermeasure that could well be costly and should be justified and optimised through comparison with the implications of introducing no such countermeasure (i.e., importing food for the local market at the usual frequency). Therefore it is important to have accurate and recent location-specific figures for the normal import fractions of dietary components that could potentially contribute significantly to dose. It would be useful to know if also imported food items might have been contaminated, as for instance large reactor accidents might contaminate areas over large parts of a continent. However, the strict European system of maximum permitted activity concentrations in marketed foods (Council Food Intervention Levels) is established to prevent spreading of significantly contaminated food across borders. It might also be that a contaminating incident only leads to food produce contamination problems in a small area of a country. Then only part of the domestic food production that is consumed within the country would be contaminated. Food distribution routes within a country are exceedingly difficult to overview or control, and a significant part of the food produced in one part of the country might well normally be consumed in an other. Individual ingestion dose estimates based on the assumption that all food produced within a contaminated area would also be consumed there would thus to some varying extent be conservative.

In most countries, the actual degree of self-sufficiency and local market share of imported foods can be complex parameters to assess, as trade routes sometimes imply that although a country produces more of a given product than it needs for the home market, a large fraction of the domestically consumed amount of that product is in fact imported from abroad. According to Arla Foods in Denmark, the imported dairy products in practise enter a ‘pool’ comprising also the Danish production, and a part of this ‘pool’ is then applied for the home market, while the rest is exported. This means that imported food may in some cases be exported shortly after, thus complicating the picture. The import figures vary widely between the Nordic countries, e.g., due to climatic reasons. For instance, some Nordic countries are great grain producers, whereas others import practically all their grains. It should also be noted that in Nordic climates, the domestic production, and thus the domestic market share, of some food products is confined to a short season.

3.1 Imported parts of foods consumed in Norway

Table 11 shows the import fractions of different foodstuffs consumed in Norway . The fraction of import may vary from year to year, and the present study covers the average import over the years 2001-2006 or 1999-2005 [1, 2].

Table 11. Imported fraction (given as percentages) of different food products consumed in Norway - Mean (min-max)

Nr	Foodstuff	Import fraction (%)	Comments	Ref
	Wheat*	**33 (25-58)**	**2001-2006**	**2**
1	Spring wheat, whole grain	33	Assumed	
2	Spring wheat, flour	33	Assumed	
3	Spring wheat, bran	33	Assumed	
4	Winter wheat, whole grain	33	Assumed	
5	Winter wheat, flour	33	Assumed	
6	Winter wheat, bran	33	Assumed	
	Rye*	**60 (18-91)**	**2001-2006**	**2**
7	Rye, whole grain	60	Assumed	
8	Rye, flour	60	Assumed	
9	Rye, bran	60	Assumed	
10	Oats	0		2
11	Potatoes	**23 (21-26)**	1999-2005	1
	Vegetables*	**45 (42-47)**	**1999-2005**	**1**
12	Leafy vegetables	45	Assumed	
13	Root vegetables	45	Assumed	
14	Fruit vegetables	45	Assumed	
	Fruit and berries*	**94 (92-95)**	**1999-2005**	**1**
15	Fruit	94	Assumed	
16	Berries	94	Assumed	
17	Milk	0		1
18	Condensed milk	**1 (0-2)**	1999-2005	1
19	Cream	0		1
20	Butter	**2 (1-3)**	1999-2005	1
21	Cheese, Rennet coagulation	**7 (4-9)**	1999-2005	1
22	Cheese, Acid coagulation	n		1
	Brown cheese (whey cheese)*	0	**Assumed**	
23	Goat's milk	0	Assumed	
24	Sheep milk	n		1
	Meat/meat products*	**5 (3-6)**	**1999-2005**	**1**
25	beef (cow)	5	Assumed	
26	beef (bull)	5	Assumed	
27	Veal	5	Assumed	
28	Pork	5	Assumed	
29	Lamb	5	Assumed	
30	Chicken	5	Assumed	
31	Roe deer meat	0	Assumed	
32	Eggs	0		1
33	Beer	n		

* Food categories reported in references [1] and [2] not directly applicable in ECOSYS

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[2] Norwegian agricultural authority (2007). Table available at http://www.slf.dep.no/portal/page?_pageid=53,418236&_dad=portal&_schema=PORTAL&p_d_i=-121&p_d_c=&p_d_v=1942&p_d_i=-221&p_d_c=&p_d_v=1942

3.2 Imported parts of foods consumed in Faroe Islands

Table 12 shows preliminary estimates of current import fractions of various food items consumed in the Faroe Islands, based on the references given below.

Table 12. Preliminary estimates of current import fractions of different food products consumed in the Faroes.

Food product	Imported fraction
Milk	~0.03
Cream	~0.03
Cheese	1
Wheat	1
Rye	1
Oats	1
Leafy vegetables	1
Root vegetables	1
Potatoes	~0.9
Fruit	1
Whale meat	0
Beef	~0.9
Pork	1
Lamb meat	~0.35
Chicken	1

References

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3.3 Imported parts of foods consumed in Sweden

The imported food fractions were calculated using the formula Import fraction = import / (production + import – export). The figures used to calculate the values shown in Table 13 were all taken from Jordbruksstatistisk Årsbok 2007.

Table 13. Imported fractions of different food products consumed in Sweden.

Food product	Import fraction
Spring wheat, whole grain	-
Spring wheat, flour	0,023
Spring wheat, bran	0,024
Winter wheat, whole grain	-
Winter wheat, flour	-
Winter wheat, bran	-
Rye, whole grain	-
Rye, flour	0,010
Rye, bran	-
Oats	0,010
Potatoes	0,094
Leafy vegetables	0,578
Root vegetables	0,132
Fruit vegetables	0,841
Fruit	0,919
Berries	0,711
Milk	0,027
Condensed milk	0,516
Cream	0,104
Butter	0,339
Cheese, Rennet coagulation	0,397
Cheese, Acid coagulation	-
Goat's milk	-
Sheep milk	-
beef (cow)	-
beef (bull)	0,323
Veal	-
Pork	0,195
Lamb	0,670
Chicken	0,403
Roe deer meat	-
Eggs	0,067
Beer	0,123

Reference

Agricultural Statistics (2002). Jordbruksstatistisk Årsbok. Swedish Statistics, Örebro, Sweden.

3.4 Imported parts of foods consumed in Finland

Data on fractions of imported foodstuffs in Finland are available annually from the statistics given in food balance sheets for the most important food commodities. Self-sufficiency in livestock products in Finland was in 2005:

pork 116 %
beef 89 %
eggs 119 %
liquid milk products 106 %

Self-sufficiency in cereals in 2005 was for wheat 111 % and for rye 32 %, and bread grain total 102 %. The figures for self-sufficiency in cereal foods range year by year from 40 to100 %. The fraction of domestic cereals, fruit and vegetables in consumption is about 54 %.

The fractions of imported foodstuffs in Table 14 are approximated values calculated from statistics on imported foodstuffs and food consumption. There is seasonal variation, especially in import of leafy and fruit vegetables. During May-September over 90% of tomato and cucumber are domestic. The summer, from mid-June to September, is the season of domestic outdoor lettuce, and import of lettuce is here low.

Table 14. Imported fractions (given as percentages) of different food products consumed in Finland.

Product	Import fraction, %
Wheat	50
Rye	85
Oats	0
Potatoes	3.6
Leafy vegetables[1]	23
Root vegetables[1]	2.5
Fruit vegetables[1]	40
Fruit	99
Berries (garden berries)	31[2]
Milk	1.5
Cream	-[3]
Butter	3
Cheese	34
Beef	14
Pork	9
Lamb	70
Chicken	9
Roe deer meat	-[3]
Eggs	2
Beer	7.6

[1] Import fraction of vegetables is given for fresh vegetables. Frozen vegetables are all imported and the fraction of frozen vegetables from the consumption of all vegetables is 3 %.
[2] The fraction of fresh imported berries is about 10%, nearly 90% are imported as frozen.
[3] No information, imported fraction very small.

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3.5 Imported parts of foods consumed in Iceland

Table 15 shows estimates of import fractions of some selected foodstuffs produced in Iceland.

Table 15. Imported fractions (given as percentages) of various food products consumed in Iceland.

Product	Import fraction, %
Wheat	~100
Rye	~100
Potatoes	41
Leafy vegetables	67
Berries	>99
Milk	0
Butter	1
Cheese	1
Beef	2
Pork	4
Lamb	0
Chicken	<1

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3.6 Imported parts of foods consumed in Denmark

Table 16 shows the fractions of different foodstuffs consumed in Denmark that are imported from abroad. The imported food fractions were generally calculated using the formula: Import fraction = import / (production + import – export), and contact was taken to Arla Foods for advice on how to address the very large fractional export and import of dairy products in relation to the home market. According to Danish Agricultural Advisory Service (2007), root vegetables are practically not imported (only 5-10 %). During the period June - October, some 75 % of all leafy vegetables consumed in Denmark are produced within the country. The rest of the year, leafy vegetables are imported. A large part of the Danish berry production is restricted to the months of June and July, where as much as half of the market is covered by domestic production. The majority of the data in Table 16 is derived from Danmarks Statistik (2001).

Table 16. Imported fractions (given as percentages) of different food products consumed in Denmark.

Product	Import fraction, %
Wheat	40
Rye	14
Potatoes	14
Leafy vegetables	25
Berries	90
Milk	10
Butter	31
Cheese	37
Beef	12
Pork	6
Lamb	80
Chicken	10

References

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4 Animal feeding regimes in each of the Nordic countries

The ECOSYS model considers radiation doses to man from consumption of food made from animals fed with contaminated feedstuffs. As demonstrated by the Chernobyl accident, various animal foodchains (e.g., grass-cow-milk-human) could cause rather high doses to population groups. Naturally, the magnitude of these doses will depend on the animal feeding regimes governing the radioactivity levels in the animal products. There can be considerable differences between feeding regimes applied within the Nordic countries. If the deposition occurs as a rather discrete event (like the Chernobyl accident), the feeding regime applied over the first few weeks, where edible vegetation still carries a significant fraction of the contamination initially deposited, will be critically important in determining the doses received from consumption of the animal products over the first year. Due to climatic differences, indoor (e.g., stored silage) and outdoor (e.g., fresh grass) feeding periods will be different in the Nordic countries, and also in relation to the South German default values in ECOSYS, which are often applied out of their context. Particularly if a contaminating incident occurs in the spring or autumn, where distinct changes to animal feeding are made at different times in different countries, it is crucial to have location-specific animal feeding regime information to avoid large errors in model predictions. It should also be noted that the types of products that animals are fed in different countries often differ, e.g., due to differences in local producibility/availability of certain fodder products or due to national agricultural policies.

4.1 Animal feeding regimes in Norway

In Norway the government has made regulations to maximise the use of nationally grown grain. This is achieved by implementing import regulations on imported grain and subsidies on nationally grown grain. The concentrated feeds used for almost all husbandry animals are from commercial feed mills. In the concentrate mixes the largest proportion of feedstuffs are spring barley, oats, wheat and soy flour (Felleskjøpet 2007). The relative content of the different grains in all concentrate mixes varies according to marked price for each kind of grain.

The figures in Table 17 are shown in the format applied in the ECOSYS model. However, the figures are given as dry matter weight per unit of time, and as ECOSYS generally operates with fresh weight figures, the Norwegian figures need to be transformed before use in ECOSYS. Indicative percentages of dry matter content that are appropriate for those calculations are: Grass: 20 %; Hay: 80 %; Cereals: 90 %.

Table 17. Feeding of animals in Norway (kg dry matter/day).

Lactating cows[1]

Dates	Julian day	Grass silage intensive[6]	Fresh grass intensive	Fresh grass extensive	Maize	Spring barley	Winter wheat	Oats	Soy flour	Lichen
01.jan	1	9.4	0	-	-	2.8	-	1.1	0,5	-
01.jun	152	0	10	-	-	1.8	-	0.7	0,3	-
15.sep	258	9.4	0	-	-	2.8	-	1.1	0,5	-
31.des	365	9.4	0	-	-	2.8	-	1.1	0,5	-

Lactating goats[1]

Dates	Julian day	Grass silage intensive[6]	Fresh grass intensive	Fresh grass extensive	Maize	Spring barley	Winter wheat	Oats	Soy flour	Lichen
01.jan	1	1.1	-	0	-	0.3	-	0.14	0,06	-
15.may	137	0	-	1.2	-	0.2	-	0.1	0,04	-
15.sep	258	1.1	-	0	-	0.3	-	0.14	0,06	-
31.des	365	1.1	-	0	-	0.3	-	0.14	0,06	-

Beef cattle[2]

Dates	Julian day	Grass silage intensive[6]	Fresh grass intensive	Fresh grass extensive	Maize	Spring barley	Winter wheat[10]	Oats	Soy flour	Lichen
01.jan	1	5.7	-	-	-	0.6	0.6	0.8	0.24	-
31.des	365	5.7	-	-	-	0.6	0.6	0.8	0.24	-

Pork[3]

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Maize	Spring barley	Winter wheat	Oats	Soy flour	Lichen
01.jan	1	-	-	-	-	1.6	0.3	0.8	-	-
31.des	365	-	-	-	-	1.6	0.3	0.8	-	-

Lamb[4]

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Maize	Spring barley	Winter wheat	Oats	Soy flour	Lichen
15.may	138	-	-	0.5	-	-	-	-	-	-
15.aug	228	-	-	0.7	-	-	-	-	-	-
15.sep	258	-	-	1	-	-	-	-	-	-

Chicken[5]

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Maize[7]	Spring barley	Winter wheat	Oats	Soy flour[8]	Lichen
01.jan	1	-	-	-	0.025	-	0.037	0.007	0.017	-
31.des	365	-	-	-	0.025	-	0.037	0.007	0.017	-

Laying hen

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Maize[7]	Spring barley	Winter wheat	Oats	Soy flour[8]	Lichen
01.jan	1	-	-	-	0.0153	-	0.0306	0.0204	0.008	-
31.des	365	-	-	-	0.0153	-	0.0306	0.0204	0.008	-

Reindeer (not presently included in ECOSYS)

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Maize	Spring barley	Winter wheat	Oats	Soy flour	Lichen[9]
01.jan	1	-	-	-	-	-	-	-	-	1.5
1.may	123	-	-	1	-	-	-	-	-	0.5
1. Oct	272	-	-	-	-	-	-	-	-	1.5
15.des	351	-	-	-	-	-	-	-	-	1.5

[1] Feeding for an average lactation and yield for Norway.
[2] Recommended feeding for bulls the last 2 months before slaughter (no cows included). Slaughter distributed evenly throughout the year.
[3] Recommended feeding the last month before slaughter (no sows included). Slaughter distributed evenly throughout the year.

[4] No feeding of ewes included. Lambs are born in March-April and slaughtered in September.
[5] Feeding recommended the last week before slaughter.
[6]According to the ECOSYS list there is only one type of grass feed from intensively managed pastures. In most countries the grass is preserved for winter as silage. Grass silage is therefore added as a feed source.
[7] Maize is here the maize grain used as a concentrate feed. In Norway all maize is imported
[8] Soy flour or other soy products are usually included in mixed concentrates to improve the protein quality of the feed. Soy is therefore added as a feed source. In Norway all soy is imported
[9]Lichen is essential feed for reindeer during the winter season.
[10] Wheat for beef cattle is wheat bran
Lactating sheep, veal and roe deer: N/A

Cattle

The most important feeds used for cattle in Norway include grass silage, fresh grass and mixed concentrates. Normal practice in the dairy production is to use grass silage as roughage fed *ad lib*. and to supplement concentrate to meet the requirement of the dairy cow (Harstad 1994). During the summer, May to October, fresh grass is used instead of grass silage. Average herd size was in 2005, 16.7 cows/farm adding up to totally 240,000 cows (Tine 2006). The farms usually produce their own grass silage and the roughage should be considered locally grown. The average yield of dairy cows were in 2005, 6540 kg milk/year (Tine 2006). At most farms the calvings are spread through out the year. The most common practice is a combined production of both milk and beef, and about 80% of the beef is produced at dairy farms (Storfekjøttkontrollen 2006). Most of the beef meat on the marked is from bulls slaughtered at 18 months of age and weighing ca 300 kg carcass weight (Storfekjøttkontrollen 2006). The ration used for beef is grass silage and mixed concentrated feed. In Table 17 the ration fed the last 2 months before slaughter is given (Matre and Berg 2001).

Goats

Goats are only used for milk production and the goat milk is produced by 32,000 goats (Tine 2006). Normal management practise is to make the goats kid from February to April, so that they are in peak or high lactation during the summer grazing period (Drabløs, 1987). Pastures used for goats are most commonly natural pastures or mountain pastures supplemented with small daily amounts of concentrates. During the indoor feeding period grass silage is fed as roughage. Average yield was in 2005, 617 kg milk/year (Tine, 2006).

Pigs

Pigs are fed only concentrates. Almost all pork is from slaughter pigs, slaughtered at ca 6 months of age, 75-80 kg carcass weight (Sakshaug, 2002). The ration used in Table 17 represents the feed given the last month before slaughter. No rations for sows are given.

Sheep

About 2/3 of the mutton is from lambs, while 1/3 is from ewes (Saueboka, 1998). In Table 17 only rations for lambs are included. Lambs are born during March to May and released on mountain pastures with their mothers from about May/June. All sheep are gathered in September and most of the lambs are slaughtered in September/October. Average carcass weight was 18.5 kg in 2007 (Røe, 2007).

Chickens and eggs
Chickens are about 31 days of age at slaughter, weighing about 900-1000 g carcass weight. The ration given in Table 17 is the feeding the last week before slaughter.

Eggs are produced from hens during the period ca 17- 77 weeks of age (Bagley, 2002). Age at slaughter and thus the end of the egg laying period is determined based on the marked situation for eggs. The laying frequency was in 2000 0.82 egg/day, each egg weighing ca 63 g (Langstrand and Aglen, 2001). The ration included in Table 17 represents the feeding during the peak egg laying period.

Reindeer
Reindeer calves are normally born late April/May. The calves are usually about 1.5 years old when slaughtered, weighing ca 19 kg after slaughter (Reindriftsforvaltningen 2007). The ration given in Table 17 is for a calf intended for slaughter in the fall as 1.5 years old.

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4.2 Animal feeding regimes in Faroe Islands

The following data for Faroese animal feeding are in general derived from personal communications, mainly with Peter Haahr, PhD, Director of Búnaðardepilin, Faroe Islands and Gunnar Bjarnason, MSc, Agricultural Advisor, Jarðargrunnurin, Faroe Islands. The format applied in Tables 18 and 19 complies with the input format applied in the ECOSYS model.

Table 18. Feeding (kg per day) of lactating sheep.

Adjusted Faroese data ("User defined")		
Date	Feed1 / Index Grass, exten/3	Feed2 / Index Hay, inten/2
01-jan	9	0
15-feb	6	1,5
15-mar	6	1,5
15-apr	6	1,5
15-maj	9	0
31-dec	9	0

Table 19. Feeding (kg per day) of lamb.

Adjusted Faroese data ("User defined")		
Date	Feed1 / Index Grass, exten/3	Feed2 / Index Hay, inten/2
01-jan	5	0
15-feb	2,5	0,5
15-mar	2,5	0,5
15-apr	2,5	0,5
15-maj	5	0
31-dec	5	0

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4.3 Animal feeding regimes in Sweden

Table 20 shows data for animal fodder in Sweden based on a survey in the Svealand, Götaland and Övre Norrland areas (Karlsson, 2007). The figures are given as dry matter weight per unit of time, and as ECOSYS generally operates with fresh weight figures, the Swedish figures need to be transformed before use in ECOSYS. Here indicative percentages of dry matter content are: Grass: 20 %; Hay: 80 %; Cereals: 90 %. The more specialised fodder items are specified in Table 21.

Table 20. Feeding of animals in Sweden (kg dry matter/year).

Animal	Fodder	kg/y
Pigs	Fodder grain*	199
	concentrate	45
Chickens	growth fodder	0,085
	Chicken fodder	3,6
Beef cattle	Grass silage	1581
	grass	2297
	Fodder grain*	114
Milk cattle	Grass silage	2850
	Grass	880
	Fodder grain*	1647
	Concentrates	1489
	Straw	220
Sheep	Grass silage	279
	Grass	402
	Fodder grain*	54
	Concentrate	17

* About equal amounts of oats, wheat and rye-wheat

Table 21. Constituents of some of the more specialised fodder items applied in Sweden, according to Svenska Lantmännen (2007).

Chickens: growth fodder		***Pigs: fodder***	
Wheat	33%	Wheat	32%
Oats	20%	Rye-wheat	13%
Rye-wheat	15%	Grain mix	8%
Rape flour	8%	Rape flour	12%
wheat bran	7%	Wheat flour	8%
Soy flour	7%	Oats	6%
Chickens: chicken fodder		Fat	2%
Wheat	47%	***Pigs: concentrate***	
Soy flour	20%	Rape flour	45%
Rye-wheat	15%	Soy flour	31%
Rape flour	8%	Chalk	12%
Animal fat	4%	***Cattle: concentrate***	
Sheep: concentrate		Rape flour	25%
Rape flour	16%	Draff	10%
Wheat	12%	Soy flour	10%
Wheat flour	10%	Wheat bran	8%
Rye-wheat	10%	Soy product	7%
Green flour	10%	Green flour	6%
Wheat bran	7%	Chalk	6%
Molasses	5%	Molasses	4%

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4.4 Animal feeding regimes in Finland

Lactating dairy cows

The main components in feeding lactating dairy cows in Finland are grass forage and concentrated feed, which accounts for 40% of the feed (as dry matter proportion). In summer grass forage is mostly fresh pasture grass (cultivated pastures) and in winter grass silage or hay. About half of the concentrated feed is home-grown cereals from the farm and the other half industrial feed. The industrial feed is made of domestic cereals and turnip rape, which is also mostly domestic. The cereal types used in feeding are oats, barley and wheat. Cows may be fed also by by-products of oil, sugar or bakery industry or concentrated feeds made of these by-products. 90 % of the feed of cows is domestic. In addition to feed, a cow needs a lot of water, 80 - 120 litres per day.

Feeding regimes vary from farm to farm. For example some farms may use more marketed feed concentrates and others only cereals from their own farm. Tables 22 and 23 give examples of feed consumption rates calculated from the feed consumption statistics of lactating dairy cows. The annual feed consumption rates of cows are substantially lower than those for lactating cows during milk production season. The time when cows are dried up (2 months) lowers the annual consumption rates.

Table 22. An example average diet of lactating dairy cows calculated for a cow per one year:

Feed	kg, dry weight	kg, fresh weight	dry matter content, %
Pasture*	830	4610	18
Hay	432	520	83
Grass silage	2310	10050	23
Cereals	1135	1320	86
Concentrated feed	592	690	86
Other feed	348	390	89

* The pastures are cultivated fields, not natural or forest pastures.

Table 23. Examples of average diets for lactating dairy cows during pasture season (120 days) and indoors feeding season (245 days):

Feed	kg/day	kg/day
	Pasture season	Indoors feeding season
Pasture	38	-
Hay	-	2
Grass silage	-	41
Cereals	3.5	4
Concentrated feed	1.5	2
Other feed	1	1.2

An example of the consumption rates for a lactating dairy cow consuming 20 kg dry matter per day and producing about 30 litres of milk per day is given in Table 24.

Table 24. An average feeding regime for a lactating dairy cow during high production season.

Feed	kg/day	kg/day
	Pasture season	Indoors feeding season
Pasture	77	-
Grass silage	-	50
Cereals	6	5.5
Concentrated feed	-	2.5
Other feed	1	2

Beef cattle

The main components of feed for beef cattle are grass silage, cereals and feed concentrate. Beef cattle are not often put out to pasture, they are fed all year round with grass silage. The average annual feeding rates per animal are 1100 kg cereals, 100 kg feed concentrates and 4500 kg grass silage. The feed concentrates may contain some imported fractions (e.g. soybean), but other components of the feed are mainly domestic.

An example of the components in feeding beef cattle from a farm is:

Silage grass	60%
Whey (only for calves)	15%
Cereals	23%
Turnip rape	1%
Mineral feed	1%

Poultry

In a poultry farm annual feeding rates per 100 hens are 3000 kg cereals and 700 kg feed concentrates. For feeding hens and chickens industrial feed is used broadly, some farms use home-grown cereals with feed concentrates. The main components in industrial feed for poultry are domestic cereals (about 65%): wheat, barley and oats, and small amounts of imported soybean.

Pigs

Pigs are fed with cereals, mainly with barley. During the time until 100 kg carcass weight (about 4.5 months) a pig eats about 200 kg cereals and 40 kg feed concentrate, which contains mainly cereals, soybean and turnip rape. Turnip rape and cereals are domestic. Daily consumption of feed ranges from one to 3.5 kg depending on the age and the rate of growth. The daily consumption of water for a small (15 kg) pig is 2 litres and for a slaughter-sized pig (90 kg) 6 litres.

Sheep

The sheep are fed with hay, silage, pasture, straw and cereals. The feed comes in most cases from own farm or neighbourhood. In summer sheep are grazing in uncultivated pastures. The proportion of cereals (oats, barley) in feed is small in summer, in winter about 0.5 kg per day. In average a lamb eats 0.5-3 kg feed per day depending on the age and size as well as the type of feed. The daily consumption of water is 4-10 litres.

Table 25 shows the the typical main constituents of fodder used for farm animals in Finland.

Table 25. Feeding of animals in Finland (kg fresh weight per day).

Beef cattle

Dates	Julian day	Grass silage inten-sive	Fresh grass inten-sive	Fresh grass exten-sive	Hay	Maize silage	Spring barley /oats	Win-ter barley	Win-ter wheat	Soy flour
01.jan	1	20	-	-	-	-	3	-	-	-
31.dec	365	20	-	-	-	-	3	-	-	-

Lactating cows

Dates	Julian day	Grass silage inten-sive	Fresh grass inten-sive	Fresh grass exten-sive	Hay	Maize silage	Spring barley /oats	Win-ter barley	Win-ter wheat	Soy flour
01.jan	1	41	-	-	2	-	4	-	-	-
31.May	151	41	-	-	2	-	4	-	-	-
01.Jun	152	-	38	-	-	-	3.5			
15.Sep	258	-	38	-	-	-	3.5	-	-	-
16.Sep	259	41	-	-	2	-	4			
31.dec	365	41	-	-	2	-	4	-	-	-

Pork

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Hay	Maize silage	Spring barley	Winter barley	Winter wheat	Soy flour
01.jan	1	-	-	-	-	-	3.5	-	-	-
31.dec	365	-	-	-	-	-	3.5	-	-	-

Sheep

Dates	Julian day	Grass silage inten-sive	Fresh grass inten-sive	Fresh grass exten-sive	Hay	Maize silage	Spring / barley, oats	Win-ter barley	Win-ter wheat	Soy flour
01.Jan	1	4	-	-	0.1	-	-	-	-	-
01.Feb	32	5	-	-	0.1	-	0.2	-	-	-
01.Mar	61	5	-	-	0.1	-	0.4	-	-	-
01.Apr	92	6.5	-	-	0.1	-	1.2	-	-	-
01.Jun	153	-	-	7.5	-	-	-	-	-	-
01.Oct	275	4	-	-	-	-	-	-	-	-
15.Oct	289	4	-	-	0.1	-	0.2	-	-	-
01.Nov	306	4	-	-	0.1	-	-	-	-	-
31.Dec	365	4	-	-	0.1	-	-	-	-	-

Chicken

Dates	Julian day	Grass silage inten-sive	Fresh grass inten-sive	Fresh grass exten-sive	Hay	Maize silage	Spring barley /oats	Win-ter barley	Win-ter wheat	Soy flour
01.jan	1	-	-	-	-	-	0.05	-	0.05	-
31.dec	365	-	-	-	-	-	0.05	-	0.05	-

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4.5 Animal feeding regimes in Iceland

Table 25 shows the typical feeding regimes applied in Iceland for agricultural animals. As can be seen, many of the ingredients are imported from abroad and thus not interesting for a scenario involving radioactive contamination of Icelandic areas.

Table 25 Feeding of animals in Iceland (kg fresh weight per day).

Lactating cow[4)]	**Dates**	**Jul. day**	**Grass silage (int.)**	**Grass fresh (int.)**	**Grass fresh (ext.)**	**Concentr.[1)]**
	01.jan	1	12 - 15			8 - 12
	15. may	136	12 - 15			8 - 12
	16.may	137		12 - 15		6 - 9
	15.sep	258		12 - 15		6 - 9
	16.sep	259	12 - 15			8 - 12
	31.dec	365	12 - 15			8 - 12

Pig (sow, adults)[5)]	**Dates**	**Jul. day**	**Grass silage (int.)**	**Grass fresh (int.)**	**Grass fresh (ext.)**	**Concentr.**
	01.jan	1				3.2
	31.dec	365				3.2

Sheep [2) 6)]	**Dates**	**Jul. day**	**Grass silage (int.)**	**Grass fresh (int.)**	**Grass fresh (ext.)**	**Concentr.**
	01.jan	1	2			0,5
	15. may	136	2			0,5
	16.may	137			2	
	15.sep	258			2	
	16.sep	259	2			0,5
	31.dec	365	2			0,5

Horse [3) 7)]	**Dates**	**Jul. day**	**Grass silage (int.)**	**Grass fresh (int.)**	**Grass fresh (ext.)**	**Concentr.**
	01.jan	1	8			< 1
	15. may	136	8			
	16.may	137			9	
	15.oct	289			9	
	16.oct.	290	8			
	31.dec	365	8			< 1

Chicken[8)]	**Dates**	**Jul. day**	**Grass silage (int.)**	**Grass fresh (int.)**	**Grass fresh (ext.)**	**Concentr.**
	01.jan	1				0,095
	31.dec	365				0,095

Laying hen[9)]	**Dates**	**Jul. day**	**Grass silage (int.)**	**Grass fresh (int.)**	**Grass fresh (ext.)**	**Concentr.**
	01.jan	1				0,14
	31.dec	365				0,14

1) The ingredients of concentrates are listed in Table 27. The amount of concentrate is commonly 40-60% of total fodder (weight). Fodder species are described in Table 26.

2) The lambs are born in May and slaughtered in late September each year. They graze in heathland/uncultivated pastures during summer. On average they eat 0.5-1 kg/day grass (fresh) their last months living.
3) A considerable part of icelandic horses graze outdoor during winter.
4) The cows graze mostly on cultivated pastures during summer
5) Consumption depends on the size (weight) of the animals. Young pigs, 6-24 weeks old, eat 1- 2.3 kg/day.
6) Icel. sheep graze in uncultivated pastures and heathland during summer
7) Icel. horses graze mostly in uncultivated pastures. Estimated values
8) Average value for 1.4 kg chicken, c. 36 days old
9) Average value for 30 - 60 weeks old hens

Table 26. Species applied in 'fodder' for lactating cattle in Iceland

Icelandic	**Latin**	**English**
Vetrarrýgresi	Lolium multiflorum Lam., var. Italicum	Italian ryegrass
Sumarrýgresi	L. Multiflorum Lam., var. westerwoldicum,	ryegrass
Hafrar	Avena sativa L.	oats
Bygg	Hordeum vulgare L.	common barley
Rúgur	Secale cereale	cereal rye
Repja	Brassica napus L., var. oleifera DC	rape
Næpur	Brassica rapa L., var. rapifera Metzg.	turnip
Mergkál	Brassica oleracea L., var. acephala	cabbage
Ertur	Pisum sativum L.	garden pea

Table 27. Examples of ingredients of some common concetrates/fodder for livestock

Main ingredients	% of content	% of content
Pigs, adults 1)		
bran	20-35	
barley	20-35	
maize corn	20-30	
soya beans, roasted	10-20	
shell chalk	1-2	
Other ingr.	1-2	
Lactating cows 1)		**Cattle, meat prod.**
maize corn	20-50	42
barley	0-20	
wheat	8-16	
bran	0-14	50
beet, meal (Beta vulgaris)	5-10	
fish meal	5-18	
molasses	5-6	5
fat	0-2	
shell chalk	1-2	2
Other ingr.	2-3	2
Chicken, meat prod. 1)		**Chicken, egg prod.**
maize	35-50	40
soya beans	25-35	22
wheat	15-20	15
soya, oil	2-6	4
shell chalk	1-2	11
fish meal	1-6	0
bran	0	3
Other ingr.	1-2	4
Sheep 2)		
fish meal	60	
barley	39	
Other ingr.	1	

1) All ingredients are imported except barley, fish meal and chalk
2) Some minor winter grazing

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Web sites applied:

www.naut.is

www.bondi.is

www.lifland.is

www.fodur.is

4.6 Animal feeding regimes in Denmark

Table 28 shows the typical main constituents of fodder used for farm animals in Denmark. Only one of the food items in the table is not considered in the standard data library of ECOSYS: soy flour. However, according to Danmarks Statistik (2001), soy is generally imported from other countries. About 9 % of the grass meal and grass pills used for fodder are, according to the same data source, imported, whereas less than 3 % of the fodder grain and pulses are imported.

Table 28. Feeding of animals in Denmark (kg fresh weight per day).

Beef cattle

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Hay	Maize silage	Spring barley	Winter barley	Winter wheat	Soy flour
01.jan	1	50	0	-	-	-	-	-	-	-
15.may	136	50	0	-	-	-	-	-	-	-
16.may	137	0	50	-	-	-	-	-	-	-
15.oct	289	0	50	-	-	-	-	-	-	-
16.oct	290	50	0	-	-	-	-	-	-	-
31.dec	365	50	0	-	-	-	-	-	-	-

Lactating cows

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Hay	Maize silage	Spring barley	Winter barley	Winter wheat	Soy flour
01.jan	1	20	-	-	-	50	-	-	-	-
31.dec	365	20	-	-	-	50	-	-	-	-

Pork

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Hay	Maize silage	Spring barley	Winter barley	Winter wheat	Soy flour
01.jan	1	-	-	-	-	-	1.5	0.4	0.3	0.5
31.dec	365	-	-	-	-	-	1.5	0.4	0.3	0.5

Sheep

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Hay	Maize silage	Spring barley	Winter barley	Winter wheat	Soy flour
01.jan	1	-	-	-	1.5	-	-	-	-	-
15.may	136	-	-	-	1.5	-	-	-	-	-
16.may	137	-	-	8	-	-	-	-	-	-
15.oct	289	-	-	8	-	-	-	-	-	-
16.oct	290	-	-	-	1.5	-	-	-	-	-
31.dec	365	-	-	-	1.5	-	-	-	-	-

Chicken

Dates	Julian day	Grass silage intensive	Fresh grass intensive	Fresh grass extensive	Hay	Maize silage	Spring barley	Winter barley	Winter wheat	Soy flour
01.jan	1	-	-	-	-	-	-	-	0.1	-
31.dec	365	-	-	-	-	-	-	-	0.1	-

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5 Discussion of differences and implications

5.1 Consumption pattern

When comparing dietary figures for the different Nordic countries, it is clear that there are very significant differences that will, at least in some types of scenarios, influence doses considerably. Figure 1 shows a comparison of the consumption of wheat and rye flour in Nordic countries. Here it is seen that a typical Danish adult consumes some 3.3 times as much rye flour as the typical Norwegian adult. Such traditional differences in diet are important to take into account in optimising efforts to reduce doses after a contaminating incident. However, as this relationship is 4.3 for the senior adults, but only 2.9 for teenagers, this particular difference between Norwegian and Danish diets seems to be declining, stressing the need for recent dietary data for the modelling. Fairly recent dietary data is available for most Nordic countries. The exception is the Faroe Islands, where the latest, and not very detailed dietary survey seems to have been conducted in 1981-82. Anyway, in the Faroe Islands and Iceland, these grain products are imported from abroad. It is also seen from Figure 1 that due to differences in climate, in the northernmost countries (Norway and Finland), practically all wheat used for consumption by humans is spring wheat, whereas in Denmark, Sweden and Germany, the majority of the wheat produced/consumed is winter wheat. This means that if a contamination occurs in the spring, the wheat plants will in Finland and Norway have undergone very little development, whereas in the more southern countries, where sowing took place already in the previous autumn, and the warmer weather would lead to a more rapid plant development, the wheat plants could be quite mature, and receive a comparatively considerably larger contaminant deposition. This would greatly affect wheat flour contamination levels in the first year harvest.

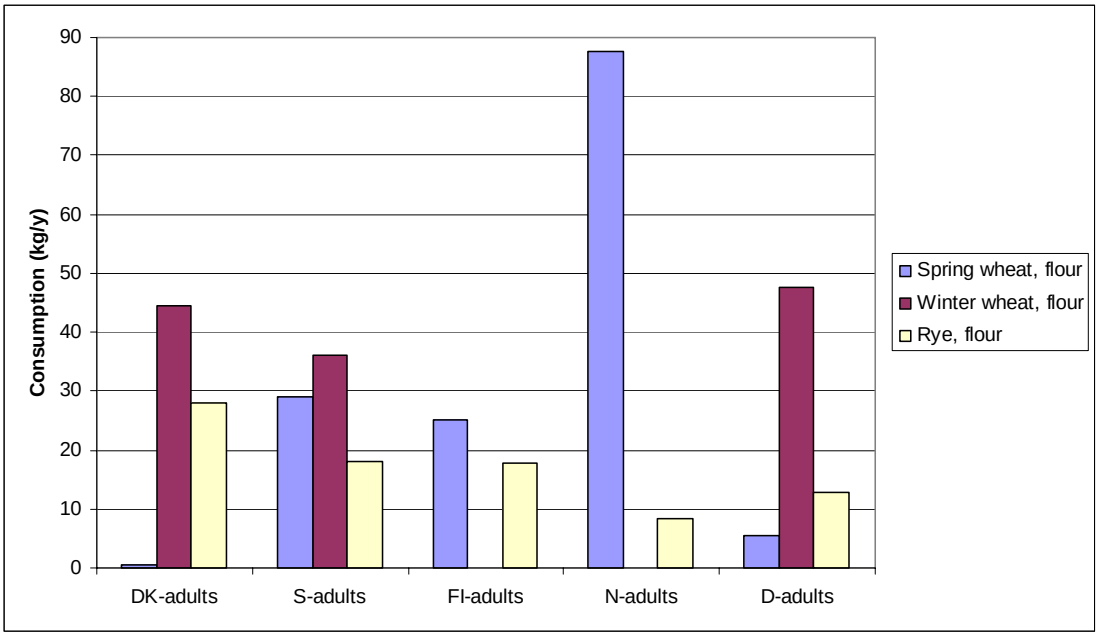

Fig. 1. Consumption of wheat and rye flour in the Nordic countries, compared with the German ECOSYS defaults (average figures for adults - ca. 30 y).

Figure 2 shows a comparison of the consumption of potatoes, leafy vegetables and root vegetables in all the Nordic countries. Also here there are great differences, as it would seem that the average Faroese adult consumes about 3 times as many potatoes as the average Icelander. Since the best available Faroese data is rather old (for these particular products from an estimate made in 1962), this difference should be considered with some caution. However, a new, unpublished rough estimate of the average for *all* age groups would be of the order of 70 kg per year (Bjarnason, 2007), indicating that this consumption is still comparatively very high. It is also seen that Danes consume relatively large amounts of root vegetables (particularly compared with Swedes), whereas Swedes and Germans seem to consume much larger quantities of leafy vegetables than do the inhabitants of the other considered countries. It should of course here be noted that consumption of directly contaminated leafy vegetables can give very high early phase doses.

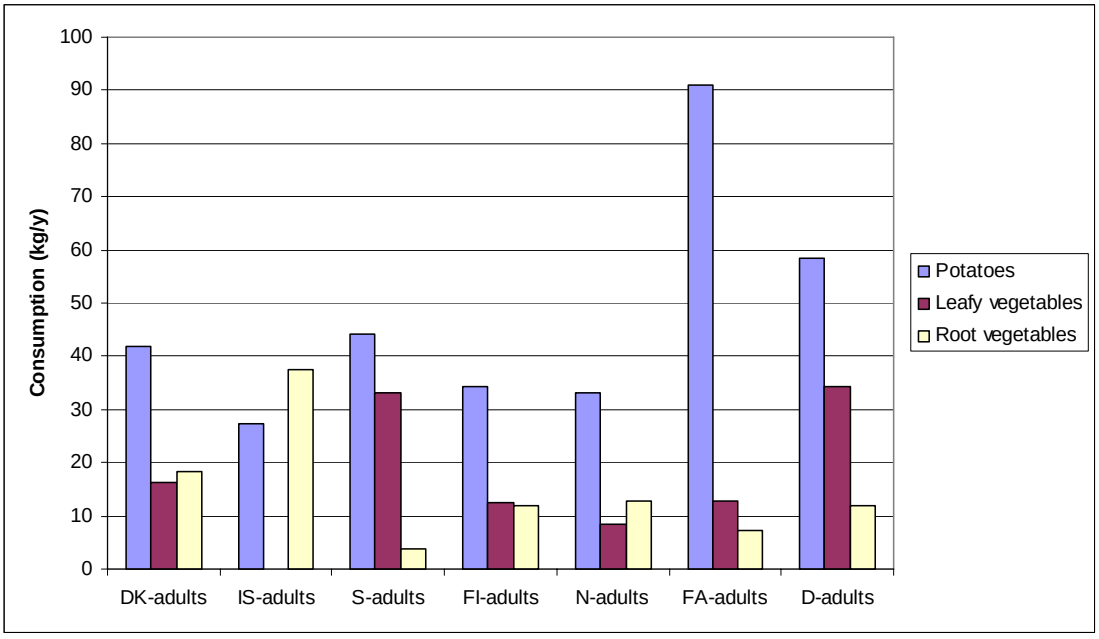

Fig. 2. Consumption of potatoes, leafy vegetables and root vegetables in the Nordic countries, compared with the German ECOSYS defaults (average figures for adults - ca. 30 y). Note that 'root vegetable' data shown for Iceland are the sum of root vegetables and leafy vegetables.

Figure 3 shows a comparison between the average consumption by adults of beef and milk in the different Nordic countries (and ECOSYS defaults). Also here, there are differences by a factor of 4-5 between some of the countries. It should be noted that the Faroese data applied are from 1936-37. As the Chernobyl accident demonstrated, the rapid milk food chain may be of very high importance in connection with a contaminating incident. The fact that very young German children consume some 3 times less milk than Nordic children of the same age group again demonstrates the importance of applying location specific input data for the ECOSYS model, as ECOSYS defaults are for some products clearly unsuited.

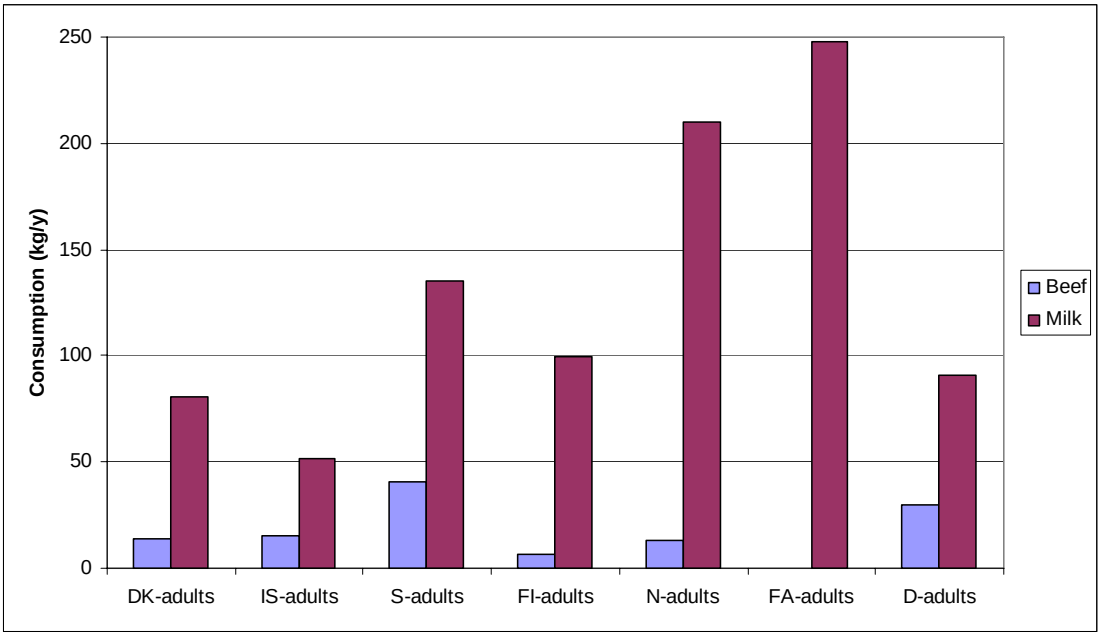

Fig. 3. Consumption of beef and milk in the Nordic countries, compared with the German ECOSYS defaults (average figures for adults - ca. 30 y).

Gender-specific data is not available for all Nordic countries. Also, the ECOSYS model does not distinguish between genders. Nevertheless, there are interesting gender-specific variations in diets, as indicated in Fig. 4. Danish adult females eat significantly more fruit than Danish adult men, whereas the men on average eat more potatoes and beef, and drink much more beer.

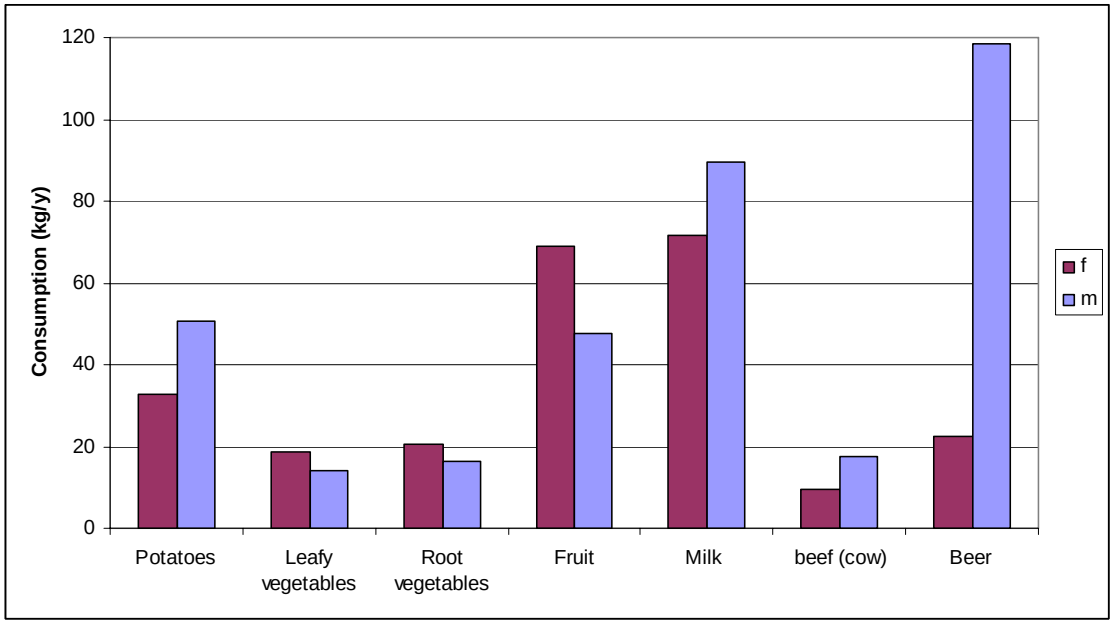

Fig. 4. Some gender differences in consumption for Danish adults. Annual average consumption of a number of foodstuffs.

Some few food items that are not included in the default ECOSYS diet list are consumed in significant quantities in some of the Nordic countries. Figure 5 shows the consumption in Norway of the traditional brown cheese. As can be seen, the amount of brown cheese consumed compared with other cheeses is high for senior adults, but considerably lower for the younger age groups, which could indicate that the overall consumption of this specific food item is likely to decline in the future.

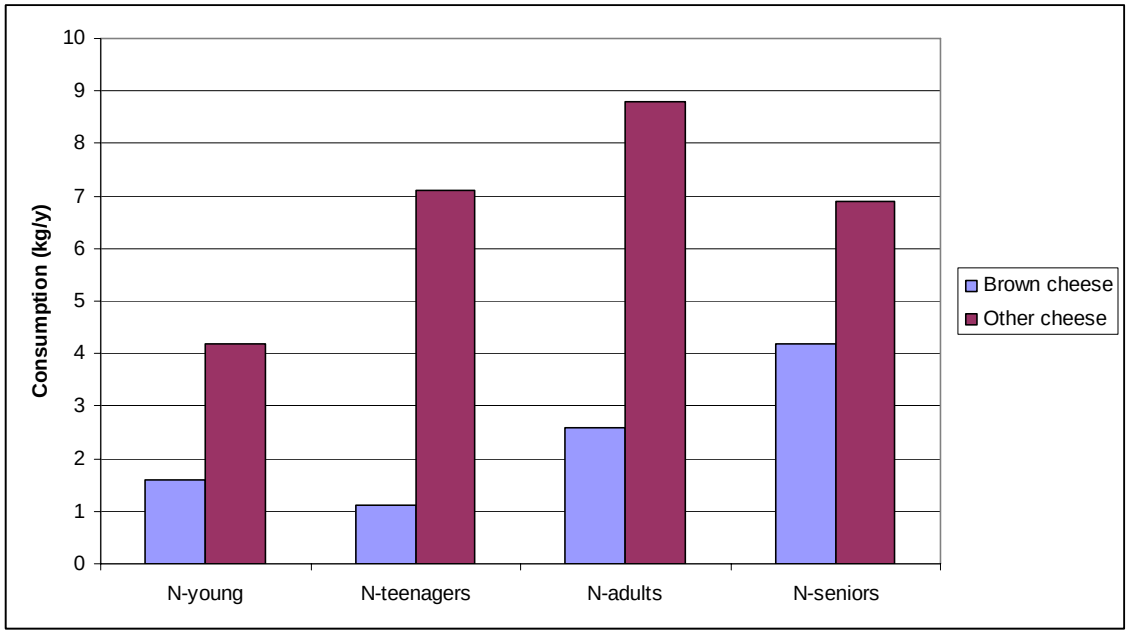

Fig. 5. Consumption of the special brown cheese and other types of cheese in Norway.

Figure 6 shows a comparison of the consumption of a number of other food items in Norway, Finland and Denmark. None of these food products are considered by default in the ECOSYS system. It should be noted that the data shown for Norway are for the most critical population sub-group (reindeer herders). Notably, the consumption of reindeer meat by the *general* Norwegian population is only about 0.5 kg per year. Further, according to the newest available data (1981-82) for the Faroe Islands, whale meat and blubber (not considered in ECOSYS) constitute significant parts of the diet (ca. 7 kg/y). However, this consumption may well be less today.

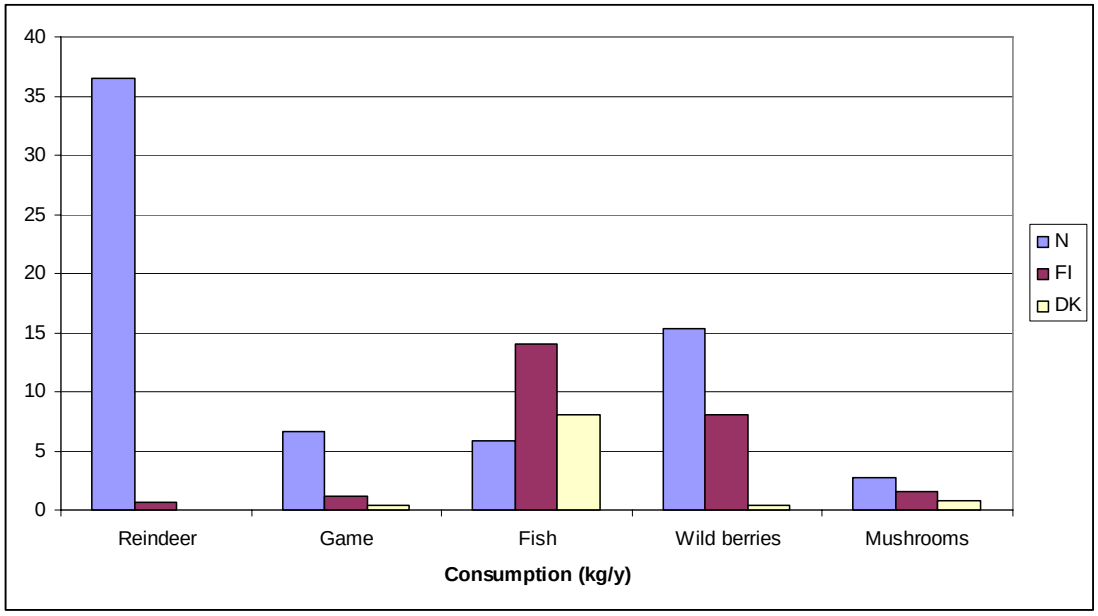

Fig. 6. Consumption of some common food items consumed in Nordic countries (kg/y), but not included in the ECOSYS model. Note: Norwegian data are specifically for the reindeer herder population.

5.2 Dose calculations

In Figure 7, an example is shown of the impact on accumulated ingestion dose to Nordic average individuals of using location-specific dietary information. The figure shows the results of ECOSYS model runs based on the ^{137}Cs air concentrations, rainfall and wet deposition recorded at Tranvik (Sweden) over the first month after the Chernobyl accident (adults - ca. 30 y) (Köhler et al., 1991). All other data (e.g., LAI, consumption seasonality, fodder regimes) are here kept as ECOSYS standard (i.e. Bavarian), to clarify the influence of considering only the diets location-specifically. No import of any foodstuffs was assumed in this example. Some of the main reasons for the differences are the high consumption of leafy vegetables in Sweden and high consumption of milk in Norway. Consumption of the special Norwegian brown cheese was not included, as transfer parameters are not available from ECOSYS. However, activity concentrations of radioactive caesium may be estimated using potassium levels in ordinary cheese (rennet) and brown cheese made from cow's milk, assuming a Cs/K ratio of unity. Applying consumption rates for adults from Table 1, the approximate individual intake of radiocasium from brown cheese will be about 4 times that of rennet cheese. By including this in the scenario modelled in Figure 7, it is seen that the contribution of this food item to the time-integrated total consumption dose to the Norwegian population will, at least under these circumstances, be rather limited (less than 10 % over any integration period).

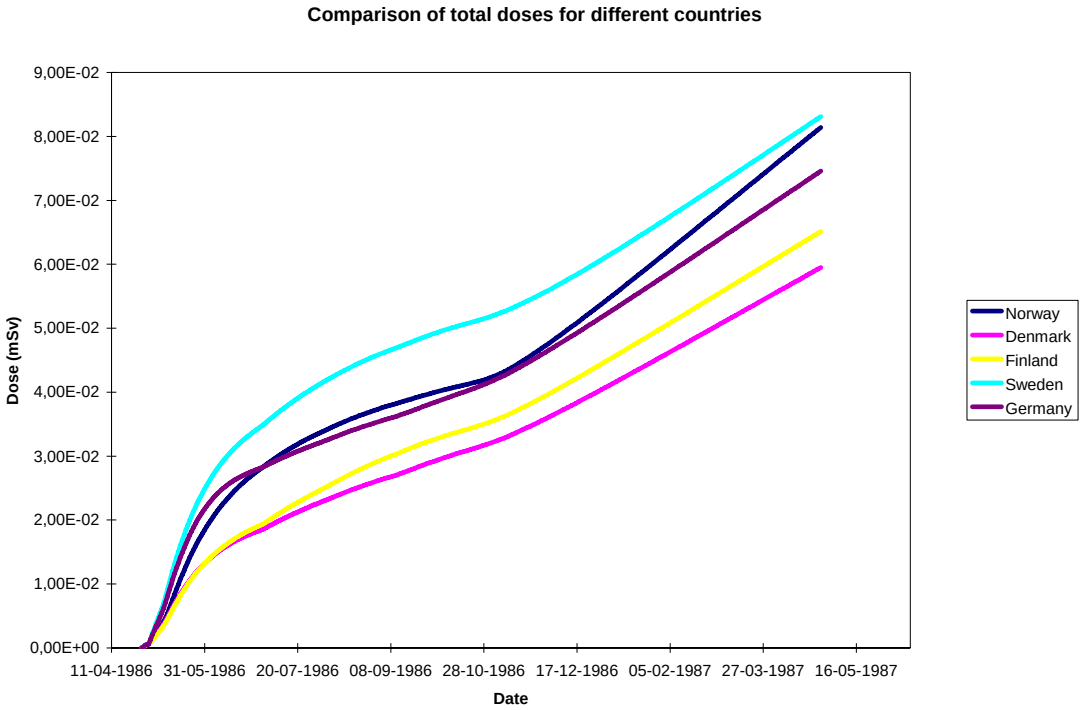

Fig. 7. Estimates of accumulated individual ingestion doses for the average population in each of the Nordic countries, using location-specific dietary information: ECOSYS runs based on the ^{137}Cs air concentrations, rainfall and wet deposition recorded at Tranvik (Sweden) in the first month after the Chernobyl accident (adults - ca. 30 y).

Table 29 shows the percentages of a selection of important dietary constituents that are produced in the different Nordic countries. Again, climatic differences are very clear (particularly Iceland and the Faroes are highly different). As stated above, the import and export movements may constitute a rather complex picture in reality, and trade routes determined by, e.g., EU membership may result in unexpected figures for the home market. Compared to the ECOSYS default (no import of any food items) it is clear that this part of the picture is important to take into account. For instance, the large amounts of leafy vegetables that are imported to many of the Nordic countries can make a considerable difference in the early phase doses in some contamination scenarios.

Table 29. Percentage of selected consumed foodstuffs produced within the country.

Food item:	S	FA	N	DK	FI	IS
Wheat	98	~0	67	60	50	~0
Rye	99	~0	40	86	15	~0
Potatoes	91	~10¤	100	86	96	59
Leafy vegetables	42	~0	55¤	75*	77#	33£
Berries	29	~0	6	10¤	69	~0
Milk	98	97¤	100	90	99	100
Butter	66	n	98	69	97	99
Cheese	60	~0	93	63	66	99
Beef	68	~10	95¤	88	86	98
Pork	80	~0	95¤	94	91	96
Lamb	33	~65	95¤	20	30	100

* Figure only valid for early June to mid-October; It is 0 the rest of the year.
¤ Assumed values.
Import of leafy vegetables is in Finland low in mid-June to September.
£ For Iceland, only the fraction for total vegetables has been identified.
n Not determined at this point.

Figure 8 shows the results of ECOSYS calculations, assuming the same scenario, as in Figure 7, except that only dry deposition was here modelled, and the imports of different food items were taken into account in-line with the figures given in Section 3 of this report. As can be seen, the differences in doses received over the first year can in this particular case be quite significant, although larger differences should be expected for some other types of contamination scenarios.

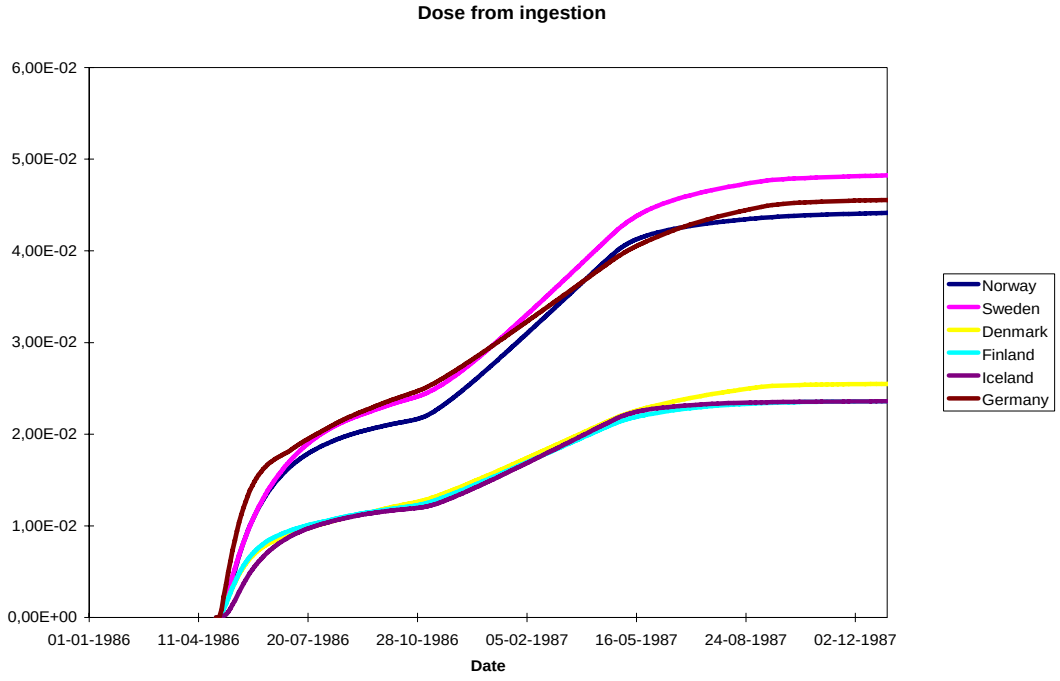

Fig. 8. Example of estimates of accumulated individual ingestion dose for the average population in each of the Nordic countries (mSv), using location-specific dietary information and import fractions: ECOSYS runs based on the ^{137}Cs air concentrations, rainfall and only dry deposition recorded at Tranvik (Sweden) in the first month after the Chernobyl accident (adults - ca. 30 y).

Figure 9 shows a short-term ingestion dose calculation 'close-up' for the same scenario, for the earliest few days, which may be particularly important, as very few countermeasures could here have been implemented. As can be seen, the resultant doses here deviate by about an order of magnitude, due to the differences in diets and import fractions.

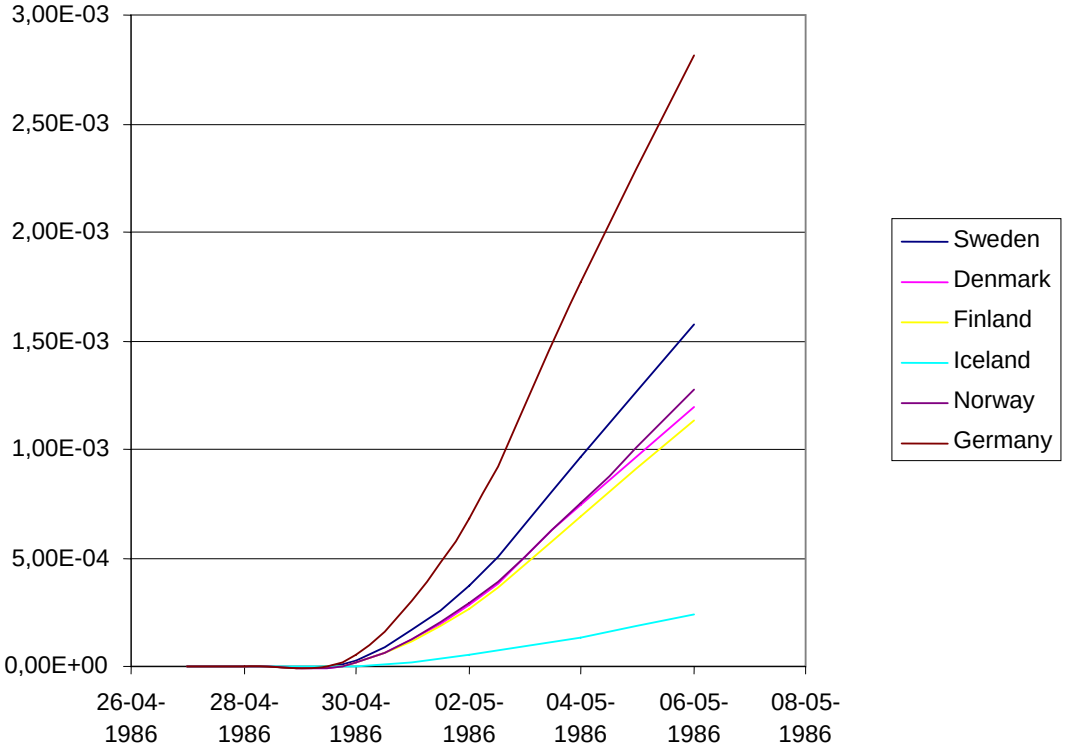

Fig. 9. Example of estimates of accumulated individual ingestion dose for the average population in each of the Nordic countries (mSv), using location-specific dietary information and import fractions: 'close-up' diagram for the first week after deposition. ECOSYS runs based on the ^{137}Cs air concentrations, rainfall and only dry deposition recorded at Tranvik (Sweden) in the first month after the Chernobyl accident (adults - ca. 30 y).

5.3 Animal feeding regimes

It should be noted that also differences in Nordic animal feeding regimes can have great bearing on doses received after a contaminating incident. For instance, Danish lactating cattle is generally kept in stables all year round, and fed with stored products (maize and grass silage), whereas Norwegian lactating cattle is grazing between the 1st of June and the 15th of September. ECOSYS calculations show that if an accident occurs in the beginning of June, the caesium concentrations in Norwegian milk, cream, butter and beef would even after six months all be one or two orders of magnitude higher than the corresponding in Danish products. For other animals, the feeding regimes are qualitatively similar for different countries, but due to different climates, the differences between indoor and outdoor feeding periods can be significant, and if a contamination occurs in the intermediate time period, the resultant

differences in animal food contamination levels can be very large. For instance Norwegian lactating cattle begin their grazing season nearly a month later than assumed in the Bavarian ECOSYS defaults, and end it nearly two months earlier. Also for instance the extensive use of mountain pastures for lambs in some countries is expected to influence doses in a long term perspective. The effect of feeding regimes needs further studying to fully understand the effect on the doses.

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6 Summary

A review of the ECOSYS model, which is the ingestion dose model applied in the European standard decision support systems ARGOS and RODOS, identified a number of points where elaboration is deemed necessary before ECOSYS should be relied on for Nordic decision making. The present study has been performed to update the ECOSYS model, which in a number of ways does not reflect current state-of-the-art knowledge, and to obtain country-specific data. It is the aim of the PardNor project to collect new data, as required, and thus enable the targeted use of ECOSYS for scenarios involving contamination of specific Nordic areas. This year's effort within the PardNor project is targeted on identifying location-specific Nordic data sets describing the typical human diets, fractions of imported food items and animal feeding regimes. In later phases of the project, it is for instance planned also to determine a more detailed methodology for calculation of contaminant uptake from soil by plants, a more accurate means of determining location-specific leaf area indexes for crops (which is essential in modelling contaminant deposition), as well as improved figures for leaching rates, fixation rates, desorption rates and resuspension enrichment factors.

For each of the Nordic countries, a dataset has been established describing the typical diets for four different age groups, ranging from young children to senior adults. Where possible, also gender-specific differences in diets have been described. A comparison of the different datasets shows that there are highly significant differences between consumption rates of some of the important food items. For instance, the average consumption of milk varies by a factor of 4-5 among the Nordic countries, and consumption of leafy vegetables varies by a factor of almost 4. Due to the differences in climate among the Nordic countries and also compared to Southern Germany, for which the default ECOSYS values apply, there are also very significant differences in the production regimes of some food items. For instance, in the northernmost countries where grain crops can be grown, the production (and thereby a large part of the consumption) is spring grain crops, whereas for instance in Denmark or Germany, winter crops are clearly dominant. This gives large deviations in growth periods and development stages of the crops - particularly in the spring. This in turn implies that first year doses from the same contaminant plume scenario can be very different among the Nordic countries, and that the modification parameters derived in the PardNor project are urgently needed.

Since some countries import practically the entire consumption of some major food items, it is important to generally examine the import patterns for the different Nordic countries, and this was also done within the project. Due to the complexity of current international trade routes, unexpectedly high import fractions were found for some food items, for which the production in the given countries was much more than sufficient to cover the home market. ECOSYS calculations for a scenario showed that the differences in consumption and production patterns could easily lead to a difference in long term ingestion doses by a factor of at least two between the Nordic countries. It was also demonstrated that early phase doses received before countermeasures can be effectively implemented may deviate by at least an order of magnitude.

Finally, typical animal feeding regimes have been examined and described for the different Nordic countries. Here it has been found that both the fodder items and the seasonal variation in their application vary considerably. For instance, in some countries, some animals will be fed with stored products (e.g., silage and hay) over a period of months, while the same type of animals are in an other country grazing on open pastures. The implications of this could, according to calculations made with the ECOSYS model, be differences in the dose contributions received over the first six months by more than one order of magnitude.

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Abstract

A review of the foodchain ECOSYS model, which is applied in the European standard decision support systems ARGOS and RODOS, has identified a number of points where elaboration is deemed necessary before ECOSYS should be relied on for Nordic decision making. The present study has been performed to update the ECOSYS model, which in a number of ways does not reflect current state-of-the-art knowledge, and to obtain country-specific data. It is the aim of the PardNor project to collect new data, and thus enable the targeted use of ECOSYS for scenarios involving contamination of specific Nordic areas. The effort in 2007 is targeted on identifying location-specific Nordic data sets describing the typical human diets, fractions of imported food items and animal feeding regimes. For each of the Nordic countries, a dataset has been established describing the typical diets for four different age groups, ranging from young children to senior adults. A comparison of the datasets shows that there are significant differences between consumption rates of some of the important food items. For instance, the average consumption of milk varies by a factor of 4-5 among the Nordic countries, and consumption of leafy vegetables varies by a factor of almost 4. Due to the differences in climate among the Nordic countries and also compared to Southern Germany, for which the default ECOSYS values apply, there are also very significant differences in the production regimes of some food items. Since some countries import practically the entire consumption of some major food items, it is important to generally examine the import patterns for the different Nordic countries. Due to the complexity of current international trade routes, unexpectedly high import fractions were found for some food items, for which the production in the given countries was much more than sufficient to cover the home market. ECOSYS calculations for a scenario showed that the differences in consumption and production patterns could easily lead to a difference in long term ingestion doses by a factor of at least two between the Nordic countries. It was also demonstrated that early phase doses received before countermeasures can be effectively implemented may deviate by at least an order of magnitude. Finally, typical animal feeding regimes have been examined and described for the different Nordic countries. Here it has been found that both the fodder items and the seasonal variation in their application vary considerably.

Key words Foodchain modelling, ingestion dose

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